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WEST INDIAN BULLETIN

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DISEASES OF LOGWOOD, COCOA-NUT, CASSAVA ETC. AT JAMAICA.

The following paper (reproduced from the *Journal of the New York Botanical Garden*, Vol. IV, pp. 1-10) contains a Report of a visit paid to Jamaica by Mr. F. S. Earle, Assistant Curator of the Museum at the New York Botanical Garden, in October and November 1902.

Mr. Earle is a Cryptogamic Botanist who during his visit devoted special attention to the diseases of logwood, cocoa-nut palms, bananas, oranges and cassava. His investigations on the spot were, necessarily, of an incomplete character, but a more extended account is proposed to be prepared when laboratory studies and inoculation experiments have been completed.

In his concluding remarks Mr. Earle draws attention to the presence in Jamaica of a number of diseases of economic plants some, at least, of which he believes are liable to prove destructive. He suggests to the Government that the Board of Agriculture in the island can do no more useful or practical work than to provide for a further study of these diseases.

Mr. Earle's report is as follows :—

I sailed for Jamaica on October 16, reaching there on October 20 and remained until November 26. The trip was undertaken on the invitation of the Hon. W. Fawcett, Director of the Jamaica Public Gardens, for the purpose of investigating certain diseases of logwood, cocoa-nuts and other economic plants. My instructions were also to secure living specimens of tree-ferns for the conservatories, and to collect fungi and other cryptogams for the herbarium. Thanks to the hearty co-operation of the Jamaica Government and the United Fruit Company, and to the invaluable aid given by Mr. Fawcett and his associates, Mr. W. Harris, and Mr. W. Cradwick, the objects of the expedition were successfully accomplished. Forty-five specimens of tree-ferns representing fourteen or fifteen species were secured and forwarded to the Garden ; 630 herbarium specimens were collected, of which nearly 500 are fungi, the remainder being lichens and mosses with a few fresh-water algae. These will be studied and lists

prepared as soon as other duties will permit. The following plant diseases were observed. In a number of cases cultures were secured of the organisms found in the diseased tissues, and a more extended account will be prepared when laboratory studies and inoculation experiments with these organisms have been completed.

LOGWOOD ROOT ROT.

On some estates, especially toward the western end of the island, logwood trees are dying in considerable numbers. The diseased trees usually occur in groups, the infection spreading slowly but in constantly widening circles. An examination of dying trees shows the roots to be badly rotted. Their surface tissues are invaded by a white fungus mycelium that is usually more abundantly developed in the space between the bark and the wood. The disease seems first to attack the small rootlets, gradually spreading to the larger roots and to the crown, when the tree dies. In many cases seemingly healthy trees near the borders of infested areas were found to have the roots on the side next the dying trees badly diseased, while on the other side they were still perfectly healthy. The fungus seems to be the mycelium of some one of the *Hymenomycetes*. Numerous species of *Polyporaceae* and *Thelephoraceae* were found on logwood stumps and logs, but in no case could their connexion with this root rot be satisfactorily proved. Whatever the nature of the fungus, leaving stumps of trees that have died from this disease in the neighbourhood of living trees is clearly dangerous. Dying trees should be dug out and the roots burned as soon as the disease can be detected. Where it is confined to certain small definite areas, as is often the case, it would be advisable to dig a trench 3 feet deep just outside of the diseased area in order to prevent its spreading underground to the roots of healthy trees. On a few of the estates examined the disease was so widely scattered that this method of treatment would not be practicable. Here it would seem best to clear the infested tract entirely of logwood, marketing such as was sufficiently mature and allowing the land to grow up in pimento and limes or reserving it for pasturage or cultivation. It should be mentioned in this connexion that pimento trees are said to die from a similar root rot in some parts of the island. If this should prove to be identical with the logwood root rot, pimento would not be available as an alternative crop.

This root rot seems to spread slowly. One old logwood chipper assured me that trees had been dying for thirty-five years on a spot that he pointed out. This area does not now include over 3 or 4 acres. This would indicate that by vigorous measures it could be controlled. The disease was found on various kinds of soils and under moisture conditions varying from dry rocky hillsides to the margin of swamps. In some cases the diseased areas were on spots where the soil was rich and deep and the moisture and drainage conditions perfect. It was not observed on the heavy clay lands towards the eastern end of the island, but whether this was due to the absence of infection or to the character of the soil could not be determined.

'BASTARD' LOGWOOD.

The logwood dye of commerce is extracted from the heart wood of mature trees of *Haematoxylon campechianum.* In Jamaica occasional trees are found in which little or no haematoxylin occurs. In its place is a substance yielding a dull, yellowish green dye. Such sticks are rejected by logwood buyers for they not only yield none of the desired colouring material, but if mixed with the normal wood in any quantity, do harm by spoiling the tint of the extract. Complaints have been reaching the Botanical Department of Jamaica, from certain quarters for some time, that the amount of this so-called bastard wood was increasing. The cause of this lack of haematoxylin in certain trees was one of the problems I was requested to investigate, and considerable time was given to it. The facts ascertained are as follows* : (1) Logwood is a variable plant showing marked difference in form, colour and texture of leaf, time of blooming, form and extent of the ribs on the trunk, colour of bark and especially in the colour dye-producing quality of the heart-wood. Four well-marked varieties are said to be recognized in Honduras and three are usually recognized in Jamaica, but they are many other intermediate forms. (2) Bastard wood is not the result of disease or of any lack of vigour. The trees producing it are perfectly healthy and normal. (3) It is not the result of soil or climatic conditions, since bastard and normal trees are found growing side by side under absolutely identical conditions. (4) It is not the result of immaturity. Aged trees may produce bastard wood, while in normal trees the heart-wood, as soon as formed, contains a good percentage of haematoxylin. These facts seem to point to heredity as the probable cause of the trouble. That is, that certain trees produce only bastard wood because they grow from the seed of a bastard tree; or in other words, that bastard logwood represents a variety of *Haematoxylon campechianum* that normally produces little or no haematoxylin, just as one Honduras variety has smaller, shorter, thinner and lighter coloured leaves. Experiments now in progress at Hope Gardens, Jamaica, and at the New York Botanical Garden with seedlings from the seed of bastard and of normal trees should in time settle this question conclusively. No data were obtained to show whether or not the trouble was increasing as is claimed by some. An increase could be readily accounted for, by the fact that on many estates a tree chipped into and found to be bastard has been allowed to stand and produce continued crops of seed, while the normal trees have been cut down on reaching maturity. A wise policy would ensure the prompt destruction of such trees whenever detected, as they have no value except for firewood, and should not be allowed to produce seed. It is unfortunate that there seems to be no constant difference in leaf or trunk by which these bastard trees can be distinguished, that would allow of their still earlier destruction.

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* I am under obligation to Dr. Amiel Bucher, Superintendent of the West India Chemical Works, for much information in regard to logwood.

COCOA-NUT BUD DISEASE.

Outbreaks of a serious disease of cocoa-nut trees have occurred in Jamaica at various times. Some years ago groves in the neighbourhood of Montego Bay* were badly injured by it and the industry was completely destroyed on the Grand Cayman † island, probably by the same trouble. At present it is attracting but little attention, although numerous cases of it exist widely scattered over the western end of the island, a few being observed as far to the eastward as Port Antonio. It was not observed to the east of a line between Port Antonio and Kingston. One of the first symptoms of the disease is the dropping of the immature nuts. In some cases the lower clusters hang on and reach maturity however. The leaves droop a little and become somewhat yellow. Often those that are just unfolding are seen to be distorted and blackened on the edges. The young flower-buds still enveloped in the spathe rot, and finally the central leaf-bud rots and the entire top falls away. Such trees are often pointed out by the planter as having been struck by lightning. Others attribute the death of the trees to a large borer said to work from the trunk up into the bud. In the numerous cases examined death was not due to either of these causes. The head of the tree was in all cases invaded by what seems to be a bacterial rot. The organism develops in the sweet, slimy coating found on all the young protected organs. It eats into the sheathing bases of the petioles and attacks the flowering sheaths. As the spathe grows the surface becomes cracked and the disease reaches the soft flower buds through these cracks. Finally it reaches the 'cabbage' or central growing point, which it soon reduces to an offensive rotten mass. The top now falls away leaving a circle of the lower leaves that had matured before the tree was attacked. These persist for a time, but, of course, finally die also, as the tree has no power of branching or of producing a new growing point. The means by which the contagion is conveyed from tree to tree could not be determined, nor could any estimate be formed of the time elapsing between infection and the death of the tree. Numerous cultures were secured and the study of the disease will be continued.

At Port Antonio the petioles and midribs of the leaves of some of the diseased trees were found to be invaded by a parasite that caused the browning and death of the tissues. This petiole disease was found on some trees that did not as yet show signs of the bud trouble. Whether or not the two troubles are caused by the same organism can only be determined by the further study of the cultures that were secured.

From our present imperfect knowledge of this disease it is impossible to suggest a remedy. Remedial measures, or rather successful preventive measures, would probably depend on the method by which the disease is conveyed from tree to tree. This can only be determined by careful and prolonged field study. The importance of the industry involved would fully

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* *Bulletin of the Botanical Department, Jamaica*, 1891, p. 2.
† *Ibid*, 1889, p. 3.

justify the expenditure and effort necessary to obtain a complete understanding of this disease. The necessity for the destruction of the contagion by the prompt cutting and burning of all infected trees is shown by the marked tendency of the disease to spread from each centre of infection.

It is claimed by some planters that a certain green-skinned variety of cocoa-nut is less liable to this disease than the reddish and yellowish kinds. The facts observed seemed to support this view. If it is confirmed by further observations it will be a factor of the greatest importance as it would make possible the selecting of a resistant race of cocoa-nuts.

COCOA-NUT WASTING DISEASE.

In the eastern part of the island between Morant Bay and Manchioneal, a disease occurs that can best be described by the above name. The nuts fall a few at a time. The lower leaves droop and fall prematurely, while the new leaves that are produced become successively smaller and less vigorous. In the final stage the leaves are reduced to less than half the normal size and the few that remain stand erect as a thin wisp at the apex of the bare stem which is seen to be abruptly tapered almost to a point. At length the tree dies, but the course of the disease is always slow, and affected trees may live for months or perhaps years. In the trees examined a white scale insect was always found at the base of the petioles and on the fruiting peduncles. The slow loss of vitality shown by these trees is a result that could be expected from the presence of this class of insects in sufficient quantity, but they did not seem numerous enough to fully account for the serious effect on the tree. In all the cases examined there was also a slow rotting of the sheathing bases of the petioles and of the fruiting sheaths. The scale insects were also observed on some trees that did not as yet show recognizable symptoms of the disease. Whether such symptoms would ultimately develop can only be determined by observations continued through a considerable period. Mr. William Cradwick, of the Jamaica Agricultural Department, has undertaken to make further field studies, and as specimens of the scale and cultures from the diseased tissues have been secured it is hoped we may ultimately gain a better understanding of this interesting but obscure trouble.

If, as seems probable, the scale is the first inciting cause of the disease, it should be possible to devise some remedial treatment. Owing to the height of the trees and the method of growth, the scales being largely sheltered by the fibrous sheathing bases of the leaves, the successful application of insecticides would be difficult but not necessarily impossible. Mr. Cradwick will undertake some experiments on this line.

An interesting experiment has been tried on one of the plantations of the United Fruit Company, in firing the dead leaves and fibres hanging on the diseased trees. The flame kills all the fruits and open flowers and most of the expanded leaves, but the apical bud is not injured and new leaves and flowers are soon developed. This seems like heroic treatment, but two trees were pointed out that had been fired six months

ago, when they were in advanced stages of the disease. Now they seem entirely recovered and are putting on a new crop of fruit. This firing of the trees has also been suggested as a remedy for the bud disease. The chances for success would seem to be much less in that case, for the disease so soon becomes deeply seated.

COCOA-NUT TRUNK BORER.

A few trees were observed where areas on the trunk, two or three feet or more in extent, had been bored full of small holes about 1 mm. in diameter. Minute white larvæ were found at the bottom of some of these burrows but none were taken in condition for identification. A rotting of the trunk soon follows these borings, and if the insect was abundant it would cause considerable loss. It was only observed in one grove, and there, only in a few trees.

COCOA-NUT TRUNK ROT.

A few cases were observed where some slight injury allowed the entrance of a rot that destroyed the entire centre of the trunk. In one case an outer rind of less than half an inch of healthy wood remained, a decomposing liquid running out when this was cut through. Strangely enough, the top of this tree still seemed healthy and vigorous, but the rot in the centre of the trunk had reached to within a few inches of the base of the bud. Such cases seem to be very rare, but they show the importance of avoiding unnecessary wounds of the trunk.

BANANA LEAF-BLIGHT.

On one locality at Stony Hill, north of Kingston, a serious banana disease was observed. It causes the browning of the vascular bundles in the veins and midrib of the leaves. This is soon followed by the blackening of the entire leaf-blade, and eventually by the decay of the leaf and petiole. It does not seem able to extend from the petiole into the tissue of the stem. The terminal bud is not attacked, but continues to push out fresh leaves. These soon become infected in turn, so that usually not more than three or four of the younger leaves are free from the disease. Infected plants are much stunted in growth and do not bear fruit. In the small field where it was first observed fully three-fourths of the plants were infected. The contagion was in this case probably introduced with the suckers that were used for planting, as these were said to have been taken from some neglected patches in the neighbourhood, and a visit to these showed that they were also infected. The disease evidently spreads slowly as it had not crossed a wide hedge-row separating this infected field from one adjoining. It may never prove troublesome, but the advisability of immediately destroying all diseased plants was strongly urged. If so destructive a disease should by any chance become widely scattered, the result would be truly disastrous.

Apparently it is due to a bacterial parasite. Cultures were

obtained and it is hoped to study the disease further. No evidence was secured as to the means by which it is conveyed to the fresh leaves or from plant to plant. So far as known it is confined to this one locality, which is at an elevation of some 1,200 feet and on red land. Such locations are not considered to be adapted to bananas, yet all uninfested plants were growing and fruiting satisfactorily.

ORANGE ROOT-GRUB.

Orange growers, especially in the neighbourhood of Bog Walk, are much troubled by a grub that gnaws the bark of the roots. Often the injury is sufficient to cause the death of the trees. Where the trees do not die, the growth ceases, the leaves turn yellow, and the crop fails. The grub is a footless larva, probably that of *Praepodes vittata*, one of the *Curculionidae*. (See *Journal of Jamaica Agricultural Society*, January, 1898, p. 11.) From what I am told of the habits of this insect it can best be destroyed when in the adult stage. The beetles are said to gather in great numbers on the orange trees, eating the foliage. If such is the case, they could be killed by arsenical sprays. They are said to be clumsy flyers and to have the habit common to many of the *Curculionidae* of falling to the ground when jarred or disturbed. This should make it possible to catch them by jarring on to sheets as is done with the peach curculio. The larvae could doubtless be killed in the ground by injections of carbon bisulphide, but whether this could be done without injury to the tree and at an expense that would make it practicable, can only be determined by carefully conducted experiments in the field. Whether tobacco or other substances worked into the soil about the tree would prevent the depositing of eggs, is perhaps worthy of trial. The insect is thought to be a general feeder and is not confined to the orange, though it seems to be particularly partial to all citrus fruits. Some growers claim that they have suffered more when practising clean cultivation than when weeds and bush are allowed to grow for part of the year, the roots of which may serve to divide the attention of the grubs.

In this connexion it may be noted that orange scale insects are not likely to prove seriously troublesome, for in the moister regions at least they are quickly destroyed by fungoid parasites. The orange rust mite occurs on the island, but it only seems troublesome on certain wet heavy soils.

CACAO STEM CANKER.

This trouble was only observed in the neighbourhood of Port Maria, but it probably occurs in other parts of the island. Slightly swollen areas occur on the trunk or larger branches. The tissues in the central part of the swellings soon die and the yellow perithecia of some Nectriaceous fungus develop on the bark. The swelling continues to grow at the margin till finally it often girdles and kills the tree. Keeping the trunks and larger branches painted or sprayed with Bordeaux mixture should be a complete protection from this disease. It would

also destroy moss and lichens and keep the trunks in a clean healthy condition. Promptly cutting out the diseased areas and painting the cut surfaces with sulphate of copper or sulphate of iron solution and then coating with tar or paint would probably in most cases save trees that are already attacked.

CACAO POD ROT.

Examples of rotting cacao pods were seen at various places. Apparently more than one species of fungus is concerned in this rotting. This point will be reported on later. This rotting is not attracting much attention, but with the Creola variety at low altitudes it is certainly very serious and under certain conditions it is liable to prove destructive to other kinds. Whether or not the blasting of the young pods is due to the growth of a fungus could not be certainly determined. This blasting occasions a very considerable loss, especially to the fall crop.

CACAO ROOT DISEASE.

There is trouble from the dying of cacao trees on certain areas. The roots examined all showed signs of having been gnawed much as in the orange trouble, but in addition the injured roots were attacked by some fungus mycelium. Want of time prevented a thorough investigation of this trouble.

CASSAVA ROOT ROT.

It was stated by some labourers that cassava roots rotted if planted on land where logwood trees had died. A cassava patch was examined that had been planted on such lands. A number of unthrifty plants were noted and on digging them up the roots were found to be enveloped in a white mycelium and to be rapidly rotting. Dead logwood stumps were near these diseased plants. This was on a rather light, upland, red soil, that was well adapted to the growth of cassava. The connexion between the cassava rot and the logwood root rot could only be inferred.

CONCLUSION.

In conclusion I would say that this somewhat hasty reconnaissance demonstrates the presence in Jamaica of a number of diseases of economic plants some at least of which are liable to prove destructive. The short time at my disposal was not sufficient for a thorough study of any of these and the few remedial and preventive measures suggested above are tentative only, and are intended simply as the basis for field experiments. I would respectfully suggest to the Jamaica Government that the Agricultural Department can do no more useful or practical work than to provide for a further study of these diseases.

While thus emphasizing the great importance of acquiring a full knowlege of such diseases as do occur, I feel like con-

gratulating the planters of Jamaica on the fact that serious diseases seem to be so few. Most countries with equally diversified crops have to contend with a much greater number of these pests.

METHODS OF CORN BREEDING.

The following paper, on methods of breeding Indian corn or maize with the view of improving the yield and quality for food purposes, as well as for the manufacture of glucose and other products is of singular importance. It embodies the results of experiments carried on in the United States for a period of six years and it is proved that, during that time, several new races of Indian corn have been produced of great industrial value.

The paper was read by the author, Dr. C. G. Hopkins, (Professor of Agronomy in the Agricultural College of the University of Illinois) before the Section of Agriculture and Chemistry of the Association of American Agricultural Colleges and Experiment Stations at Atlanta, Georgia, October 8, 1902. Both Dr. Morris, and Mr. Fawcett who were present on the occasion were impressed with the value of the work carried on by Dr. Hopkins and others, and it is of the utmost importance that experiments on similar lines be carried on in the West Indies.

Already something has been attempted in this direction by Mr. John Barclay, the Secretary of the Jamaica Agricultural Society (*Journal Jamaica Agricultural Society*, Vol. VII., p. 9), and at Antigua by the Hon. F. Watts and Mr. Sands (*Agricultural News*, Vol. I., p. 229, and *Report of Economic Experiments, Antigua*, 1901-1902, pp. 4-5).

Dr. Hopkins' paper is reproduced in the *West Indian Bulletin* in the hope that it will receive the careful attention it deserves and that, as a result, the improvement of the quality and yield of Indian corn will henceforth be included amongst the foremost efforts of the scientific workers in the West Indies.

METHODS OF BREEDING CORN.

BY CYRIL GEORGE HOPKINS, Ph.D.

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It is a well established fact that there now exist markets and demands for different kinds of corn.

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* Reprinted from *Bulletin* No. 82, University of Illinois, Agricultural Experiment Station, Urbana. December, 1902.

The price of corn varies, say, from ½ cent to 1 cent per pound.

The cost of protein in the principal stock-feeding states varies from 3 to 5 cents per pound. In other words, the protein is several times more valuable per pound than corn itself. Consequently, stock feeders want more protein in corn. (Very possibly the feeders in the southern states want more carbohydrates to supplement their present more abundant supplies of nitrogenous food stuffs.)

The price of corn starch varies from 2 or 3 cents to 5 or even 10 cents per pound, depending upon the wholesale or retail nature of the sale. The manufacturers of starch and of glucose-sugar, glucose-syrup, and other products made from starch want more starch in corn.

In its own publication a large commercial concern, which uses enormous quantities of corn, makes the following statements:—

'A bushel of ordinary corn, weighing 56 pounds, contains about 4½ pounds of germ. 36 pounds of dry starch. 7 pounds of gluten, and 5 pounds of bran or hull, the balance in weight being made up of water, soluble matter, etc. The value of the germ lies in the fact that it contains over 40 per cent. of corn oil, worth, say, 5 cents per pound, while the starch is worth 1½ cents. the gluten 1 cent, and the hull about ½ cent per pound.

'It can readily be seen that a variety of corn containing, say, one pound more oil per bushel would be in large demand.

'Farmers throughout the country do well to communicate with their respective agricultural experiment stations and secure their co-operation along these lines.'

These are statements and suggestions which should, and do, attract the attention of experiment station men. They are made by the Glucose Sugar Refining Company of Chicago, a company which purchases and uses, in its six factories, about fifty million bushels of corn annually. According to these statements, if the oil of corn could be increased one pound per bushel, the actual value of the corn for glucose factories would be increased 5 cents per bushel; and the President of the Glucose Sugar Refining Company has personally assured the writer that his company would be glad to pay a higher price for high oil corn whenever it can be furnished in large quantities. The increase of 5 cents per bushel on fifty million bushels would add $2.500,000 to the value of the corn purchased by this one company each year. The glucose factories are now extracting the oil from all the corn they use and are unable to supply the market demand for corn oil. On the other hand, to these manufacturers, protein is a cheap by-product, and consequently, they want less protein in corn.

Corn with a lower oil content is desired as a feed for bacon hogs, especially for our export trade. Very extensive and thorough investigations conducted in Germany and Canada having proved conclusively. that ordinary corn contains too much oil for the production of the hard firm bacon which is

demanded in the markets of Great Britain and Continental Europe.

The methods of corn breeding devised by the Illinois Experiment Station and now used not only by us, but also by the Illinois Seed Corn Breeders' Association, and, to some extent, by other experiment stations and other corn breeders, have for their object the improvement of corn—in yield and in quality. In the main the methods are now the same as we have employed for the past six years, and they have given results which enable us to assert with confidence, that by these methods corn can be improved in a very marked degree and for many different purposes. The yield of corn can be increased, and the chemical composition of the kernel can be changed as may be desired, either to increase or to decrease the protein, the oil, or the starch.

Following is a brief description of the methods of corn breeding which we practise and which we have recommended to others :—

PHYSICAL SELECTION OF SEED CORN.

The most perfect ears obtainable of the variety of corn which it is desired to breed should be selected. These ears should conform to the desirable standards of this variety and should possess the principal properties which belong to perfect ears of corn, so far as they are known and as completely as it is possible to secure them. These physical characteristics and properties include the length, circumference, and shape of the ear and of the cob ; the number of rows of kernels and the number of kernels in the row ; the weight and colour of the grain and of the cob ; and the size and shape of the kernels. In making this selection the breeder may have in his mind a perfect ear of corn and make the physical selection of seed ears by simple inspection, or he may make absolute counts and measurements and reduce the physical selection almost to an exact or mathematical basis.

In this connexion let me suggest that there is some danger of corn breeders making too much of what might be called fancy points in selecting seed ears. We should learn the facts which are facts and not base our selections too much upon mere ideas and opinions. For example, it is not known that ears whose tips are well filled and capped with kernels are the best seed ears. Indeed it is not improbable that the selection of such seed ears will cause the production of shorter ears and a reduced yield per acre. It is true that the percentage of shelled corn from a given ear is the greater, the greater the proportion of corn to the cob, but our interest in that percentage is very slight compared to that of yield per acre, and perhaps for the greatest possible yield of shelled corn per acre it requires that the ears shall have good sized cobs. Possibly the corn which shall ultimately surpass all others for yield per acre will have tapering and not cylindrical ears. These are some of the points regarding which men have some ideas and opinions but as yet we have no definite facts, and we shall need several years more to obtain absolute knowledge regarding

some of these points. Let us base our selections of seed corn first upon known facts and performance records, and secondly, upon what one may call his 'type' of corn.

CHEMICAL SELECTION BY MECHANICAL EXAMINATION.

The selection of seed ears for improved chemical composition by mechanical examination of the kernels is not only of much assistance to the chemist in enabling him to reduce greatly the chemical work involved in seed corn selection, but it is of the greatest practical value to the ordinary seed corn grower who is trying to improve his seed corn with very limited service, if any, from the analytical chemist. This chemical selection of seed ears by mechanical examination, as well as by chemical analysis (which is described below), is based upon two facts:—

(1) That the ear of corn is approximately uniform throughout in the chemical composition of its kernels.

(2) That there is a wide variation in the chemical composition of different ears, even of the same variety of corn. These two facts are well illustrated in Table I.

TABLE I. PROTEIN IN SINGLE KERNELS.

	Ear A, protein, per cent.	Ear B, protein, per cent.	Ear C, protein, per cent.	Ear D, protein, per cent.
Kernel No. 1	12·46	11·53	7·45	8·72
Kernel No. 2	12·54	12·32	7·54	8·41
Kernel No. 3	12·44	12·19	7·69	8·73
Kernel No. 4	12·50	12·54	7·47	8·31
Kernel No. 5	12·30	12·14	7·74	8·02
Kernel No. 6	12·49	12·95	8·70	8·76
Kernel No. 7	12·50	12·84	8·46	8·89
Kernel No. 8	12·14	*	8·69	9·02
Kernel No. 9	12·14	12·04	8·86	8·96
Kernel No. 10	12·71	12·75	8·10	8·89

* Determination lost by accident.

It will be observed that, while there are, of course, small differences among the different kernels of the same ear, yet each ear has an individuality as a whole, the difference in composition between different ears being much more marked than between different kernels of the same ear.

The uniformity of the individual ear makes it possible to estimate or to determine the composition of the corn by the examination or analysis of a few kernels. The remainder of the kernels on the ear may then be planted, if desired. The wide variation in the composition between different ears

furnishes a starting point for the selection of seed in any of the several different lines of desired improvement.

The methods of making a chemical selection of ears of seed corn by a simple mechanical examination of the kernels is based upon the fact that the kernel of corn is not homogeneous in structure, but consists of several distinct and readily observable parts of markedly different chemical composition. (See illustrations.) Aside from the hull which surrounds the kernel, there are three principal parts in a grain of corn :

A B

FIG. 1.—CORN KERNELS IN CROSS SECTION.
A. High-protein kernel, little starch.
B. Low-protein kernel, much starch.
(*After the author's illustrations.*)

(1) The darker coloured and rather hard and horny layer lying next to the hull, principally in the edges and toward the tip end of the kernel, where it is about 3 millimeters, or $\frac{1}{8}$ of an inch, in thickness.

(2) The white starchy-appearing part occupying the crown end of the kernel and usually also immediately surrounding, or partially surrounding, the germ.

(3) The germ itself which occupies the central part of the kernel toward the tip end.

These different parts of the corn kernel can be readily recognized by merely dissecting a single kernel with a pocket knife, and it may be added that this is the only instrument needed by anybody in making a chemical selection of seed corn by mechanical examination.

The horny layer which usually constitutes about 65 per cent. of the corn kernel contains a large proportion of the total protein in the kernel.

The white, starchy part constitutes about 20 per cent. of the whole kernel, and contains a small proportion of the total protein. The germ constitutes only about 10 per cent. of the corn kernel, but, while it is rich in protein, it also contains more than 85 per cent. of the total oil content of the whole kernel, the remainder of the oil being distributed in all of the other parts.

By keeping in mind that the horny layer is large in proportion and also quite rich in protein and that the germ, although rather small in proportion is very rich in protein, so that these two parts contain a very large proportion of the total protein in the corn kernel, it will be readily seen that by selecting ears whose kernels contain more than the average proportion of germ and horny layer, we are really selecting ears which are above the average in their protein content. As

a matter of fact, the method is even more simple than this, because the white starchy part is approximately the complement of, and varies inversely as, the sum of the other constituents; and to pick out seed corn of high protein content, it is only necessary to select those ears whose kernels show a relatively small proportion of the white starchy part surrounding the germ.

FIG. 2. CORN KERNELS IN CROSS SECTION.
A. High oil content, large germ.
B. Low oil content, small germ.
(*After the author's illustrations.*)

As more than 85 per cent. of the oil in the kernel is contained in the germ, it follows that ears of corn are relatively high or low in their oil content, according as their kernels have a larger or smaller proportion of germ.

In selecting seed corn by mechanical examination for improvement in composition we remove from the ear a few average kernels: cut two or three of these kernels into cross sections, and two or three other kernels into longitudinal sections and examine these sections as they are cut, usually simply with the naked eye.

If we are selecting seed ears for high protein content we save those ears whose kernels show a small proportion of the white starch immediately adjoining or surrounding the germ. If selecting corn for low protein content we look for a larger proportion of white starch surrounding the germ. Our results have shown that the white starch in this position, that is, surrounding the germ toward the tip end of the kernel, is a better index of the protein content than the starch in the crown end.

If we are selecting seed ears for high oil content we save those ears whose kernels show a large proportion of firm and solid germ: while if seed of low oil content is desired we look for a small proportion of germ in the kernel.

It should be emphasized that it is not the absolute, but proportionate, size or quantity of germ or of white starch which serves as a guide in making these selections.

CHEMICAL SELECTION BY CHEMICAL ANALYSIS.

In selecting seed corn by chemical analysis we remove from the individual ear two adjacent rows of kernels as a representative sample. This sample is ground and analysed as completely as may be necessary to enable us to decide whether the ear is suitable for seed for the particular kind of corn which it is desired to breed. Dry matter is always

determined in order to reduce all other determinations to the strictly uniform and comparable water-free basis. If, for example, we desire to change only the protein content, then protein is determined. If we are breeding to change both the protein and the oil, then determinations of both of these constituents must be made.

For a satisfactory breeding plot, about twenty to forty selected seed ears are required. If the breeder desires to make only physical improvement then he should select, say, forty of the most nearly perfect ears which it is possible to pick out by inspection or by exact physical measurements. If it is desired to improve the composition or quality of the corn as well as the physical properties, then at least 200 physically perfect ears should be selected, and from these 200 ears, the forty ears which are most suitable as seed for the particular kind of corn which it is desired to breed should be selected. either by mechanical examination of sections of kernels, which anybody can make, or by chemical analysis, or by a combination of these two methods. In our own work we now commonly select by physical inspection or measurement the 200 ears; then, from these 200 ears, we select by mechanical examination of sections of kernels the best fifty or one hundred ears, and from this lot we finally select by chemical analysis the best twenty to forty seed ears for planting. This combination of methods effects a very satisfactory seed selection and requires only one-half as much chemical work as would be required if the method of chemical analysis alone were employed.

Table II [on the following page] shows very fairly the degree of seed improvement which may be accomplished by these different methods of selection, when breeding to change only the protein content of corn.

It may be stated that equally satisfactory results may be obtained in chemical selection by mechanical examination for securing seed ears of high or low oil content. For example, the writer has selected by mechanical examination, from a lot of 272 ears of corn, eighteen ears for high oil content which averaged 5·24 per cent. of oil; and, from the same lot of corn, thirty ears were selected for low oil content which averaged 4·13 per cent. of oil, making an average difference of 1·11 per cent. of oil.

If the method of mechanical examination alone is employed in making the chemical selection. then, if possible, there should be some chemical control of the work. at least until the breeder has become sufficiently skilled, or has had sufficient experience, to feel that he knows how to make a chemical selection of seed ears by mechanical examination of kernels. Such a chemical control does not involve a large amount of chemical work. In Illinois the Experiment Station offers such a chemical control to farmers who will agree to make the selection of the best possible seed, both by physical inspection of ears and mechanical examination of kernels, and who will further agree to secure data and breed the corn in accordance with our directions.

This control is effected by analysing only two samples

of corn each year; one composite sample of the rejected ears, five average kernels being taken from each ear, and one composite sample of the twenty to forty selected seed ears, twenty average kernels being taken from each of these ears, and each of these two composite samples being properly labelled and analysed.

TABLE II. SOME FAIR ILLUSTRATIONS OF ACTUAL RESULTS OBTAINED IN SELECTION OF SEED CORN.

(Protein, average per cent.)

Variety.	200 average seed ears.	50 ears selected by mechanical examination.	28 ears selected by chemical analysis.	10 best seed ears.	Best single seed ear.
Silver Mine	10·00	9·47	8·77	7·97	7·00
Boon County White...	10·57	9·72	9·36	8·84	8·69
Leaming	11·96	11·36	10·79	10·08	8·82
Leaming	11·96	12·44	13·33	14·03	14·63
Leaming	11·27	11·84	12·43	13·12	14·71
Yellow Dent	11·14	11·64	12·11	12·55	13·24
Riley's Favourite ...	11·02	11·38	12·41	12·99	15·78
Burr's White... ...	12·48*	12·88	14·36	14·87	15·71
Burr's White... ...	9·20†	9·10	7·77	7·56	7·08
Leaming	11·26	12·14‡			
Leaming	11·26	10·67‡			

* Average protein content of ten field rows of Burr's White after four years' breeding for high protein.

† Originally from same stock of Burr's White as preceding, but bred four years for low protein.

‡ Two lots of 42 ears each selected from the same lot of 200 ears for two breeding plots, high protein and low protein, the seed for which is selected by physical inspection and mechanical examination but without chemical analysis of individual ears.

One of the best selections which has yet been made by mechanical examination was accomplished last spring by a farmer who is breeding corn for higher protein content. Out of a lot of 165 ears of corn he selected fifteen ears whose protein content averaged 1·48 per cent. higher than that of the 150 rejected ears, as was determined by the chemical analysis of a composite sample from each of the two lots. Because of the chemical control which the station affords him, he knows each year just how much he has accomplished.

If the purpose of breeding a kind of corn is principally to change its content of a single constituent, as to increase protein, then the selection of the best forty ears is simple and regular by either method; but if it is desired to effect changes in the content of two constituents, as to increase the protein and to increase the oil in the same corn, then one could hardly expect to make much progress in both directions, if he relied solely

upon mechanical examination of kernels for chemical selection of seed ears. Even after the chemical analyses of 100 ears have been made it requires some computation to determine which are really the best forty ears. For example, an ear may be desirable for seed because of its high protein content, but it may not be sufficiently high in oil. In order to reduce the selection to an exact basis, we have adopted simple mathematical computations for all such cases.

For high protein and high oil in the same corn, we multiply the percentage of protein by the percentage of oil and use the product as the selection coefficient, the forty highest products designating the forty best ears.

For low protein and low oil we multiply the percentages together and use the lowest product as the selection coefficient.

For high protein and low oil in the same corn, we divide the percentage of protein by the percentage of oil and use the highest quotients as our selection coefficients.

TABLE III. SELECTION OF SEED CORN FOR HIGH PROTEIN AND HIGH OIL.

No. Ear.	Protein in corn.	Oil in corn.	Selection coefficient.
1	11·17	6·03	67·30
2	12·66	4·90	62·00
3	13·60	4·92	66·89
4	10·85	4·55	49·89
5	11·01	5·72	62·97
6	11·50	4·77	54·81
7	14·71	5·56	81·75
8	10·07	4·73	47·62
9	13·14	5·44	71·53
10	10·19	5·80	59·10
11	11·01	5·97	65·78
12	10·39	4·73	49·13
13	13·96	5·28	73·72
Average	11·87	5·26	62·50

For low protein and high oil we divide in the same manner, but use the lowest quotients for selecting the best ears.

Table III illustrates the value of this method as applied to the selection of the best seed ears for both high protein and high oil.

It will be observed that some ears which are high in only one desirable constituent (see No. 2 and No. 10) must be discarded because the selection coefficients which they give are even below the average; while other ears which may be quite low in one constituent (see No. 1 and No. 3) still furnish acceptable selection coefficients.

THE BREEDING PLOT.

The forty selected seed ears are planted in forty separate parallel rows, one ear to a row, consequently the breeding plot should be at least forty corn rows wide and long enough to require about three-fourths of an ear to plant a row. It is well to shell the remainder of the corn from all of the forty ears, mix it together, and use it to plant a border several rows wide entirely around the breeding plot, to protect it, especially from foreign pollen.

In my judgement one of the most practical and satisfactory locations for the breeding plot is in a large field of corn planted with seed which is as nearly as possible of the same breeding as that planted in the breeding plot itself. The stock seed for this field should always be selected from the previous year's breeding plot and it may well include as many of the 160 rejected ears as are known to be above the average of the 200. Or, if the breeding plot can be well isolated from all other corn fields and still occupy good soil, this also makes a very suitable location for it.

The very best ears of seed corn are planted in the centre rows of the breeding plot, the remainder of the ears being planted in approximately uniform gradation to either side, so that the least desirable ears among the forty are planted in the outside rows: and in the final selection of the best field rows from which the next year's seed ears are to be taken, some preference is given to the rows near the centre of the plot.

While we are not yet ready to make absolute statements regarding the matter, nevertheless, from the data which we have secured, and are securing upon the subject, we now recommend that every alternate row of corn in the breeding plot be completely detasseled before the pollen matures, and that all of the seed corn to be taken from the plot be selected from these twenty detasseled rows. This method absolutely prohibits self-pollination or close-pollination of the future seed. By self-pollination is meant the transfer of pollen from the male flower of a given plant to the female flower of the same plant ; and by close-pollination is meant the transfer of pollen from the male flower of one plant to the female flower of another plant in the same row, both of which grew from kernels from the same seed ear.

The transfer of pollen from one plant to another plant which grew from kernels from a different seed ear, we term cross-pollination. We have been for several years accumulating data which show that *artificial* self-pollination is very injurious to the vitality and vigour of the seed produced, and we have also secured data pointing toward an injurious effect of close-pollination even by natural methods, so that we feel justified in recommending, at least tentatively, the use of cross-pollination in seed corn breeding.

It is also recommended that in the twenty rows of corn which are not detasseled no plants which appear imperfect, dwarfed, immature, barren, or otherwise undesirable, should be allowed to mature pollen. Detasseling is accomplished by

going over the rows two or three times and carefully pulling out the tassels as they appear.

Occasionally an entire row is detasseled because of the general inferiority of the row as a whole.

FIELD SELECTIONS BASED ON PERFORMANCE RECORDS.

As the corn crop approaches maturity we are then ready for the first time to begin at the real beginning in the selection of seed corn; that is, with the whole corn crop and the whole corn plant, as it stands in the field.

We then make our first selection of seed corn from the field rows (each of which is the progeny of a separate single ear) on the basis of performance record. Each of the twenty detasseled rows is carefully examined. Some of them are discarded for seed purposes by simple inspection, and with some rows this decision may be made early in the growing season; because, when each field row is planted from a separate individual ear, that row has an individuality which in many cases is very marked. It may show very imperfect germination (in the most careful work the germinating power of each ear is ascertained before planting), it may be of slow growth, produce small, weak plants, or numerous barren stalks. The plants may be tall and slender or very thick and short. In one row the ears may be borne high on the stalks, while in the adjoining row they may average one or two feet nearer the ground. One row may yield more than twice as much corn as an adjoining row on the same kind of soil. As a matter of fact, when one begins to breed corn by the row system (one seed ear to each row), he is usually surprised to find that the plants in some rows are so very different from those in others, as will be seen from data from one of our 1901 breeding plots, which are given in Table IV (p. 20).

We take no seed corn from a row which produces a large proportion of imperfect plants, barren stalks, small ears or a low yield, even though a few apparently good seed ears might be found in the crop which that row yields.

The points to be considered in the selection of the field rows, and finally in the individual plants from which seed ears may be taken should include the per cent. of 'stand' of plants, the height and physical proportions of the plant, the character and amount of foliage, the position of the ear on the stalk, the length and size of the ear shank, the per cent. of ear-bearing plants, the time of maturity, the total yield of the row, the average weight of the ears, and the number of good seed ears which the row produces.

Some of these points can be determined by inspection; some require actual counts and measurements or weights.

The corn from each of the detasseled rows which have not been rejected by inspection is now harvested. First, all of the ears on a row which appear to be good ears, and which are borne on good plants in a good position and with good ear shanks and husks are harvested, placed in a bag with the number of the row, and finally weighed together with the remainder of the

crop from the same row. The total weight of ear corn which the row yields is the primary factor in determining the ten best rows from which all of the 200 ears for the next year's selection must be taken; and yet no corn breeder should follow even this rule absolutely or blindly. If it should happen that one of these ten best yielding rows, although slightly higher in yield, is nevertheless plainly inferior to some other row in the number of good ears produced, the row selection should be changed accordingly. Yield is of first importance, but it should not exclude all other points. It is more practical and profitable to produce 99 pounds of good ears than 100 pounds of 'nubbins.' Other things being equal, or nearly so, preference is also given to the rows nearest the centre of the field, for reasons explained and well illustrated in Table IV.

TABLE IV. PERFORMANCE RECORD OF BREEDING PLOT, 1901.

(Breeding for high protein).

Field Row No.	Protein in seed ear.	Weight of ear corn in crop.
1	12·06	91·0
2	12·17	86·0
3	12·19	98·5
4	12·26	99·5
5	12·31	77·0
6	12·40	**118·0**
7	12·66	**116·0**
8	12·83	54·5
9	12·90	**107·0**
10	15·78	**103·0**
11	12·93	87·0
12	12·90	**127·5**
13	12·72	**113·0**
14	12·45	**123·5**
15	12·32	**103·5**
16	12·31	92·0
17	12·23	85·5
18	12·18	**117·0**
19	12·07	**140·5**
20	12·06	97·0
Average	12·59	101·9

In the final selection of the forty seed ears we prefer to have as many as possible of the ten best field rows represented, and we frequently sacrifice slight advantages in chemical composition for the sake of having such a large representation, because of the possible future evil effects of too close in-breeding.

Each lot of twenty ears (more or less) from each of the ten best rows and, finally, each single ear of the forty seed ears ultimately selected is kept labelled, and permanent records are made of the number and the description of the ear, the composition of the grain, performance record of the row, etc., so that as the breeding is continued an absolute pedigree is established, on the female side, for every ear of corn which may be produced from this seed so long as the records are made and preserved. We also know, absolutely, that we have good breeding on the male side, although the exact individual pedigrees of the male cannot be known and recorded. The corn which we first began to breed (see *Bulletin* No. 55, Illinois Experiment Station) we are this season growing in five different breeding plots in Illinois, and it is now being grown in two or three other states; and every ear which is grown this year in any of those breeding plots has an established and recorded pedigree for seven generations. For example, each of the ears of corn which was grown the past season in our high protein breeding plot has a recorded pedigree showing the protein content of its dam, of its grand-dam, of its great grand-dam, of its great, great, grand-dam, of its great, great, great, grand-dam, and its great, great, great, great, grand-dam.

In conclusion let me say that, to the practical corn breeder, I would urge only three things:—

First: Adopt the row system, plant twenty to forty good seed ears, one ear to a row; then select your seed for the next year, on the basis of performance record, from about ten rows which produce the highest yield and the best ears.

Second: Breed corn for a purpose. If you wish to feed corn, breed and grow high protein corn. If you wish to grow corn for the starch and glucose factories, breed and grow corn the factory wants.

Third: Until we have facts, don't devote too much time to 'fancy points,' such as trying to produce kernels on the tip end of the cob, or trying to reduce the size of the cob, or trying to make the tip end of the ear as large as the butt, or pulling out suckers, or doing other things the ultimate effect of which is unknown. It is not yet known with any degree of certainty whether such things are beneficial, injurious or without effect, on the production of the crop.

And don't feel that you can't breed corn even if you are unable to detassel barren stalks. Last year we had fields with 50 per cent. of barren stalks,—this year in some fields from that seed we have about five-tenths of one per cent. of barren stalks, and these examples fairly illustrate the tremendous effect of soil and season and condition of growth, as compared with breeding, upon the production of barren stalks. Barren stalks bear no ears, and the whole tendency of nature's law is to breed them out, even without the intervention of man. As a matter of fact, in order to give to barren stalks an equal chance with ear-bearing plants to propagate themselves, we should be obliged to detassel every ear-bearing plant in the field. In studying this problem it should be borne in mind

that the female parent of the barren stalk was not barren.

It is probably much more important that we absolutely prevent self-pollination and close-pollination by detasseling alternate rows, but even this practice is still an experiment. It is very true that exceedingly poor corn has been produced by artificial or *hand* self-pollination, but recent experiments have also shown that corn may be degenerated by artificial cross-pollination; and it should be understood that our recommendation to detassel alternate rows in the breeding plot is tentative, and I certainly would not urge this practice. Probably such detasseling will prove somewhat helpful to the corn breeder, but we know that very great improvement can be made without detasseling at all, simply by selecting seed on the basis of performance record and for desirable quality or composition.

NOTES ON RECENT WORK ON VEGETABLE FERMENTS.

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During the past few years a considerable amount of research has been carried out upon the ferments occurring in plants. These ferments are of interest for two reasons: (1) on account of the role they play in the internal processes of plants; (2) on account of their economic importance. Ferments and their action have long been recognized in the animal kingdom. For the purpose of the present article it will be sufficient to state that three of the more important animal ferments are:—

(1) *Ptyalin.* The active principle of saliva. It has the power of converting starch into sugar, and acts in an alkaline medium.

(2) *Pepsin.* Found in the gastric juice of the animal stomach. Converts fibrin into peptone. Active only in an acid medium.

(3) *Trypsin.* The ferment of the animal pancreas. Digests fibrin etc., carrying the process further than pepsin. Acts in an alkaline medium.

DIASTASE.

In the vegetable kingdom starch is commonly found as a reserve food. The seeds of Indian corn and wheat, and the tubers of sweet potatos and yams, may be cited as examples

in this connexion. These stores of starch, which man devotes to his own use, are in reality reserves the plants have put by for their own future wants. Starch, as such, is useless to a plant as food. It is insoluble, and insoluble substances cannot be carried from one part of a plant to another. Starch to be of an actual use to the plant must be converted into a soluble substance. Since 1814 it has been known that germinating barley grains contain a substance capable of converting starch into sugar. This fact was ascertained nearly twenty years before it was discovered that the saliva contained a body with similar power. The plant ferment was called *diastase* and is comparable with ptyalin. Diastase has been demonstrated to be present in sprouting potatos, germinating seeds, etc. Diastase plays another important role in the plant economy. It is well known that the green parts of plants manufacture starch, from carbon dioxide and water in the presence of sunlight. A great portion of the starch so made is afterwards carried away to other parts of the plant. The process has already been described in detail in this journal* and it is sufficient to note that once again diastase has been demonstrated to be the active agent. Further research has shown that diastase is of wide-spread occurrence in plants and that it plays an essential part in their life processes.

PROTEID-SPLITTING FERMENTS.

It will be convenient to treat the two other animal ferments together. Pepsin and trypsin are distinguished by their power to act as nitrogenous or proteid bodies, whereas diastase and ptyalin act on starch but have no action on proteids. Speaking broadly, pepsin and trypsin differ in their action in degree rather than in kind. The resulting body when pepsin acts on proteids is a substance called peptone, whereas trypsin can not only convert the original proteid into peptone, but decomposes this still further into simpler bodies known as amides. Trypsin is of the same general nature in its action as pepsin, but more powerful. Trypsin is exceedingly wide-spread in the animal kingdom, and although it is rather anticipating matters, it may be well to quote here Prof. Vines' statement that 'tryptic digestion is of general occurrence in the animal kingdom, and is apparently the sole process in many invertebrates. It is not improbable that this may be expanded into the proposition that tryptic digestion is a property of all living organisms, and that it is the more primitive form of the digestive process.'†

It is in this group of proteid-splitting or proteolytic ferments that a large amount of research has been carried out recently in plants. The three ferments which have been examined with the greatest attention are those of the papaw tree (*Carica Papaya*), the pine-apple (*Ananas sativus*), and the pitcher plants (*Nepenthes*).

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*W. G. Freeman. 'Notes on the Formation of Cane sugar in the Sugar-cane, *West Indian Bulletin*, Vol. II., pp. 251-61.

† S. H. Vines. 'The Proteolytic Enzyme of Nepenthes. III. *Annals of Botany*, Vol. XV., p 573.

FERMENT OF THE PAPAW.

The juice of the papaw has, for many years, been credited with the power of rendering meat tender. The power was found to be due to a ferment, contained in the milky juice of the fruit, leaves, etc., and now known as *papain*. This ferment was first investigated carefully by Wurtz in 1879. It has been proved beyond all doubt to have the power of digesting nitrogenous bodies such as the fibrin of meat, albumen, etc. There is still some question as to the actual nature of the products of digestion. Professor Vines in a recent paper (*Annals of Botany*, Vol. xvii, p. 261) states that the ferment of the papaw is 'allied to the trypsin of animals.' On the other hand, Mr. L. B. Mendel concludes as a result of a series of experiments, that papain belongs to a class of ferments distinct from either pepsin or trypsin (*American Journal Medical Science*, August 1902, reviewed in the *Botanical Gazette*, Vol. xxxv., p. 65). The most important point, namely, that the juice of the papaw possesses a ferment capable of digesting proteids is acknowledged by all workers. The uncertainty attaches only to the actual products of digestion.

The digestive power of papaw juice has caused it to become of medicinal value. The ripe fruit is employed as a digestive aid. It is important to notice that ferments are easily destroyed if heated above a certain temperature, and for this reason the uncooked fruit only possesses the digestive power. Fortunately the utilization of the useful properties of the papaw is not restricted to those who can obtain the fresh fruit. It has been found possible to collect and to dry the juice without destroying the ferment. A small industry in 'crude papain' is at the present time carried on at Montserrat and the method of preparation has been described with figures in the *Agricultural News*, Vol. I., page 9.

FERMENT OF THE PINE-APPLE.

A good account of the ferment of the pine-apple is given by Professor J. Reynolds Green (*Ferments and Fermentation*, p. 195 *et seq.*) Attention was first called to this ferment in 1891, and since then its action has been carefully examined. The juice of the pine-apple is markedly acid, and the ferment can be isolated by saturating the juice with crystals of common salt, etc. The ferment has been termed *bromelin* from the name of the natural order (*Bromeliaceae*) to which the pine-apple belongs. Bromelin is a very active ferment. Professor Reynolds Green records the following experiment which well illustrates its digestive powers :—'300 grammes of moist fibrin were warmed at 40° C., with 2,500 c. c. of ·025 per cent. hydrochloric acid and ·25 grammes of bromelin, for five hours. By the end of this time the fibrin had been all dissolved except a small flocculated residue.' Bromelin is most active at about 60° C., and even when heated as high as 70° C. shows considerable power.

On account of the presence of bromelin, the use of the pine-apple has been advocated in the *Lancet* as an aid to digestion. In the same journal it was suggested that 'unless the

pine-apple is preserved by heat there is no reason why the fruit should not retain its digestive power.' We have previously pointed out, in the *Agricultural News* (Vol. I., p. 107), that this is improbable as the heat employed in sterilizing the pine-apples before the tins are sealed up in all probability destroys the ferment.

FERMENT OF PITCHER PLANTS.

The pitcher plants (*Nepenthes*) are a well-known and curious group of insectivorous plants characterized by bearing pitchers at the ends of their leaves, sometimes one foot or more long, and two to three inches in diameter. These pitchers usually contain a liquid into which insects commonly venture, and are drowned. It has been stated that the insects drowned in this liquid are decomposed by bacterial action and the products of their decomposition afterwards absorbed by the plants. On the other hand, Professor Vines, as the result of a series of experiments, comes to the conclusion that the plant actually excretes into the pitchers a ferment, *nepenthin*, which digests the captured insects. His latest paper on this subject 'The Proteolytic Enzyme of Nepenthes' (*Annals of Botany*, Vol. xvi., p. 563) is confirmatory of his earlier work. He states: 'My results make it apparent that the three enzymes, nepenthin, bromelin and papain, have essentially the same proteolytic action, which is tryptic.' Nepenthin differs from bromelin and papain in being active only in an acid medium, and in this point it acts similarly to pepsin of the animal stomach.

PROTEOLYTIC FERMENTS IN OTHER PLANTS.

Professor Vines has recently carried his investigations further, and the results of some of his experiments have been published in a general paper on 'The Proteolytic Enzymes of Plants' (*Annals of Botany*, Vol. xvii., p. 237.) In this paper he has collected evidence to show that 'a proteolytic enzyme is widely distributed in plants,' occuring amongst flowering plants such as the cucumber, melon, pumpkin, banana, tomato, apple, orange, lettuce, cabbage, and among 'flowerless' plants, in the mushroom and the hart's-tongue fern. The exact ferment occurring in all these cases has not yet been definitely ascertained. The interesting point is the apparently wide-spread occurrence in the vegetable kingdom of a group of ferments formerly supposed to be confined to animals and a few exceptional plants. As Professor Vines remarks (*loc. cit* p. 263) 'Just as diastase was, step by step, discovered to be everywhere present in the body of the plant, so now the same has been done for the proteolytic enzyme. No doubt the analogy also holds good with regard to their respective functions. Just as diastase facilitates the transference of temporarily deposited starch, so the proteolytic enzyme renders possible the distribution of the elaborated proteids. ...If leaves generally, or at any rate commonly, produce a proteolytic enzyme, it ceases to be remarkable that a similar enzyme should be formed by the leaves of certain of

the "insectivorous" plants. The peculiarity of these plants is now limited to this— that their enzyme should be poured out at the surface, so that it digests proteids supplied from without by the captured insects: whereas in ordinary plants the enzyme is retained within the tissue to digest and so render mobile the proteids that are formed there.'

OXIDIZING FERMENTS OR OXIDASES.

All the ferments considered so far, agree in that their action is probably one of hydrolysis, breaking up the body acted upon, after the addition of water. The evidence is convincing in the case of diastase and is believed to hold good for the proteid-splitting ferments as well. During the last few years another group of ferments have been shown to exist which cause the direct addition of oxygen to the bodies acted upon. In accordance with this characteristic feature of their action they have been termed oxidizing ferments or *oxidases.*

Research on this group of ferments has been largely carried on by French physiological chemists, and an excellent resumè of the facts ascertained previous to 1898 is given by Prof. J. Reynolds Green (*Science Progress*, Vol. vii, p. 253.)

FERMENT OF THE LAC TREE.

In Japan an industry is carried on in the preparation of lacquer varnish from the milky juice of *Rhus vernicifera* (*Anacardiaceae*), a plant fairly closely related to the mango. Incisions are made in the trunk and the sap is collected and spread out in thin layers. This liquid is originally white. As it dries it darkens in colour, passing through brown to a brilliant black. It has been ascertained, mainly by the work of the Japanese chemist Yoshida, that the active agent in these changes is a ferment, now known as *laccase.* He also demonstrated that this ferment acts 'most energetically at a temperature of 20° C., but only when oxygen and moisture are both present.' *

Our further knowledge of this ferment has been largely due to the work of the French chemist Prof. Claude Bertrand.† He found laccase present, to give a few examples only, in the roots of beet and carrot, in potatos and artichokes, in the fruits of the apple, pear, etc., in the leaves of lucerne or alfalfa, asparagus and the flowers of *Gardenia.* Bertrand found manganese associated with laccase, and considered that this metal played an important part in the activity of the ferment. Colour changes, such as take place when the cut surface of an apple is exposed to the air are probably due to the activity of laccase or some similar oxidizing ferment.

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* J. Reynolds Green. *The Soluble Ferments and Fermentation.* First Edition, p. 292.

† Claude G. Bertrand. 'Sur la recherche et la présence de la laccase dans les végétaux.' *Comptes Rendus.* T. 121, p. 166.

FERMENTS OF TOBACCO.

The most important, from the economic point of view, of the oxidizing ferments are perhaps those which appear to play an essential part in the fermentation of tobacco. Our present knowledge of these ferments is largely due to the investigations of Dr. Oscar Loew, formerly of the Department of Agriculture of the United States of America.*

As the result of his researches Dr. Loew has demonstrated that in the first stage of manufacture,—the 'curing' of the leaf—certain changes take place. The starch in the leaf disappears, the active agent being probably diastase. The proteids also decrease in amount as the result of the action of a trypsin-like ferment. During the second stage—the fermentation or sweating of the leaf—further changes take place, including a decrease in the amount of tannin, and nicotine present.

It was formerly considered that bacteria were the essential agents in the fermentation of tobacco. Dr. Loew produces evidence to negative this view and says: 'The conclusion which must invariably be reached is that the bacteria found on the fermenting tobacco leaves do not participate in any way in the fermentation process, but that they are accidentally present and probably only in the form of spores.'

For various reasons Dr. Loew was led to surmise that the changes in the fermentation of tobacco were due to oxidizing ferments. By suitable experiments he was able to demonstrate the presence of two oxidases in the juice of fresh tobacco leaves. In summarizing his work he says, 'The so-called tobacco fermentation is not caused by bacteria.

'The principal changes which take place during the curing and fermenting of tobacco are due to the action of soluble enzymes or ferments.

'Several kinds of enzymes act in the curing process, (a) an amylolytic enzyme, (b) a proteolytic, and (c) two oxidizing enzymes, while in the fermenting process the main changes are due to the oxidizing enzymes alone, and consist in the oxidation of nicotine and other compounds.

'The development of colour and aroma is due principally to the action of the oxidizing enzymes.'

In his later work Dr. Loew has discovered another enzyme in the tobacco leaf, to which he has given the name *catalase.*

IMPORTANCE OF FERMENTS TO PLANTS.

The above examples suffice to demonstrate clearly the important part played by ferments in plants. By means of diastase many plants are enabled to render soluble and utilize

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* Oscar Loew. *Curing and Fermentation of Cigar Leaf Tobacco.* Report No. 59, U.S. Department of Agriculture.

——. *Physiological Studies of Connecticut Leaf Tobacco.* Report No. 65. U.S. Department of Agriculture.

——. *Catalase. A new enzyme of general occurrence with special reference to the Tobacco plant.* Report No. 68. U.S. Department of Agriculture.

the otherwise useless, insoluble starch stored up as reserves of food in their tubers and seeds. Nor does the usefulness of diastase end here. It has been shown to be present in almost all parts of the plant and to play an important part in the translocation of starch manufactured in green leaves in sunlight.

In the animal kingdom a ferment of similar action to diastase occurs in the ptyalin of the saliva.

Many animals subsist to a great extent on proteid food and their power to render the insoluble proteids of use, in other words, to digest them, is due to various ferments such as trypsin and pepsin. There is, as yet, some uncertainty whether pepsin actually occurs in plants. Ferments of similar action to trypsin certainly occur. By their aid insectivorous plants, for example, the pitcher plants, digest the insects they capture. In other plants such as the papaw and the pine-apple, similar ferments occur and are put to economic uses by man.

The third group of ferments, the oxidases, have a wide distribution in both the animal and vegetable kingdoms. Of the actual part they play in the life processes of the organisms containing them, but little is known with certainty. They are, however, of considerable economic interest, playing important parts, for example, in the production of lacquer varnish and the fermentation of tobacco. The recent work carried out in connexion with ferments is of great value, not only for its physiological interest, but because it has given a clear insight into formerly little understood, industrial processes, and will almost certainly lead to great practical advances in the near future.

COTTON-GROWING IN THE WEST INDIES.

BY D. MORRIS, C.M.G., D.Sc., M.A. F.L.S.,

Imperial Commissioner of Agriculture for the West Indies.

A good deal of interest is being taken at the present time in the possible revival of cotton-growing in the West Indies. The following information is published in the *West Indian Bulletin* with the view of placing the subject in a concise form for the consideration of the planting community:—

The experiments in cotton-growing, started in 1900 at St. Lucia by the Imperial Department of Agriculture, were instituted with the view of bringing into cultivation lands that had once been in sugar but had been abandoned owing either to the poverty of the soil or the arid nature of the climate. It was hoped, as in Carriacou, that some varieties of cotton would withstand conditions unfavourable for the sugar-cane and bring in returns that would still leave a margin of profit to the planter.

Later, owing to the rapid fall in the price of sugar the idea of taking up the cultivation of cotton as subsidiary, or in lieu of that of sugar, was seriously entertained by the planters at Montserrat, Antigua and St. Kitt's. There are at present about 600 acres under experiment cultivation in cotton in these islands.

It is too early yet to estimate the results of the abolition of the Sugar bounties; but unless Central Factories can be established in the islands above named and at Barbados, or the price of muscovado sugar can be maintained uniformly at not less than about £9 to £10 per ton, it is not improbable that cotton-growing may be successfully substituted for sugar in many localities. The result would be that a cotton industry would flourish in these colonies side by side with sugar, cacao, fruit, and other industries.

There is no doubt that the West Indian Colonies are well adapted for the cultivation of cotton. They formerly grew comparatively large quantities, and in fact a hundred years ago supplied nearly the whole of the cotton from the New World shipped to Europe. In 1801, 25,000 bales were exported ; in 1836, 20,000 bales. Afterwards cotton was discarded in favour of sugar, and other crops, yielding larger profits. There was a slight revival of cotton-planting in the West Indies during the civil war in America in 1863-65, but since that time cotton has almost disappeared from our lists of exports, the only locality where the cultivation has survived being the small island of Carriacou—a dependency of Grenada.

It is desirable to repeat that cotton-growing is not likely to offer the prospect of greater gain or more congenial employment than sugar if the prices of the latter are moderately good. It is only in localities where sugar-growing cannot be carried on at a profit that cotton should, at once, be attempted to be cultivated on a large scale.

Where it is clearly evident that sugar cannot be produced at a profit, the cultivation of cotton would offer employment to a large section of the community, and if careful attention were devoted to growing the varieties of cotton best suited to the soil and climate and these, happen, as in the case of Sea Island cotton, to command relatively high prices, the industry would have a reasonable chance of success.

DEMAND FOR COTTON.

An important point in favour of a continuance of the present demand for cotton is the fact that since 1898 the United States is not only the leading country in the production of raw cotton but also the leading country in the consumption of this article.

In 1900, the consumption of cotton in Great Britain was 3,269,000 bales while in the United States it was 3,727,000 bales.* If, as is probable, this supremacy is maintained, the United States will have less cotton to export in the future

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* Bales weighing 500lb. each.

and Great Britain will be more dependent on other sources. The following figures taken from the *Board of Trade Journal* indicate the countries whence Great Britain receives at present, its chief supplies of raw cotton :—

	1902.	1901.
	Bales.	Bales.
American	2,958,917	3,150,797
Brazilian	236,768	51,557
East Indian	68,890	80,912
Egyptian	487,474	389,371
Miscellaneous	59,106	70,207
Total	3,811,155	3,742,844

It will be observed that while the total imports into Great Britain in 1902 were about 70,000 bales in excess of those of 1901, the supply from the United States in 1902 was about 192,000 bales less than in 1901. This deficiency was more than made up by the increased shipments of Brazilian cotton. These rose from 51,557 bales in 1901 to 236,768 bales in 1902.

An important factor that may tend to still further increase the general demand for cotton is the rapid expansion of its use in competition with wool, flax and silk. At one time in Great Britain wool took the first place in the value of its textile industries. In fact, about 1800 the value of cotton fabrics and yarn amounted to only about 5 per cent. of the whole. A little later cotton took second rank, but from 1830 onwards it has taken the lead and has gone on steadily gaining ground until it has attained the first place not only in respect of exports but also in respect of the weight and value of the fabrics consumed at home. The average annual consumption of the three fibres in the period 1898-1900, in million pounds, was as follows : cotton 1504, wool 497, flax 215. The consumption of cotton in Great Britain is therefore more than three times that of wool and more than seven times that of flax. There is little doubt, that cotton is now largely used where formerly wool and flax were required. This is no doubt also due to the advance in the art of preparing and mixing cotton with other fibres, and in colouring and designing cotton fabrics.

As regards even silk, it is admitted that 'to-day there is hardly a fabric where silk is employed but that mercerized cotton can, to a certain extent, replace it.' *

*Year book of the U.S. Department of Agriculture, 1901, pp. 193 - 206.

CHIEF SOURCES OF SUPPLY OF COTTON.

The chief sources of the supply of raw cotton other than the United States are Brazil, East Indies and Egypt. The same factor is probably operating in Brazil as in the United States, viz: that a larger proportion of raw cotton is being retained in the country to be manufactured locally. Similar circumstances are also believed to be operating in India as her own mills are taking a large and increasing proportion of her crops. At all events there has been a considerable falling off of late in the imports of Indian cotton into Great Britain.

The supply of cotton from Egypt, however, has been steadily increasing. The total exports from that country in 1900 were 1,132,000 bales of 500lb. each. Egyptian cotton resembles Sea Island cotton and is used for fabrics requiring a smooth finish and silky lustre. It is, moreover, of a brownish hue and is, amongst spinners, considered a specialty.

As already shown, the imports of Egyptian cotton into Great Britain in 1901 were 389,371 bales and in 1902, 487,474 bales. The United States also take some Egyptian cotton. In 1900-01 the imports into that country were 69,571 bales.

FAVOURABLE CONDITIONS IN THE WEST INDIES.

A few of the points in favour of re-establishing a cotton industry in the West Indies may be mentioned. There are large stretches of cleared land, formerly under cultivation in sugar-cane, well adapted for the cultivation of cotton. The soil and climate have, long ago, been proved to be favourable and the present labour supply, especially in such islands as Barbados, Montserrat, Antigua and St. Kitt's, is likely to be equal to the demand, and available at a lower cost than anywhere in the United States.

The variety of cotton suitable for cultivation in the West Indies is the 'Sea Island' cotton. This is a special kind almost identical with Egyptian cotton and usually commands the highest price.

It may be added that the planters regard favourably the prospect of at least a partial return to cotton-planting in these colonies. It will readily fall into line with the estate routine with which they are already familiar, and it will require almost identically the same kind of field preparation as sugar. Irrigation and the use of expensive artificial manures will be unnecessary. If the whole of the cotton seed that is produced were converted into meal, and fed to animals and the resultant manure applied to the land, it is probable that no other fertilizers would be required.

It is also in favour of a cotton industry that expensive machinery and buildings are not required and that the crop could be grown and exported within a period of about six to eight months from the time of planting. Further it is probable that a central ginning factory costing a few hundred pounds would be capable of dealing with the crop produced on a comparatively large area.

The Imperial Department of Agriculture has in hand a pamphlet containing hints and suggestions for cotton planting in the West Indies. This it is hoped will be shortly issued.

In addition the Department is prepared to obtain the best varieties of Sea Island cotton and to supply it in quantities to suit the requirements of the planters at cost price. Orders for cotton seed for planting in July and August next should be forwarded to the Officers of the Department in the several colonies as early as possible.

THE COTTON-SEED INDUSTRY IN THE UNITED STATES OF AMERICA.

In the *Year Book* for 1901 of the Department of Agriculture for the United States of America, pp. 285-98, appears an interesting paper entitled 'The Cotton-Seed Industry' by Mr. Charles M. Daugherty of the Division of Statistics.

This paper demonstrates in a striking manner the enormous strides made by the cotton-seed industry in the United States of America during the past twenty years. This increase has been mainly due to the important industrial uses now made of cotton-seed oil, and oil cake. In 1901 over 49,000,000 gallons of cotton-seed oil were exported from the States, in addition to over 47,000,000 gallons retained for home consumption.

Cotton-seed oil cake now enjoys a very high appreciation as a cattle food and is in correspondingly high demand. It is indeed more highly appreciated as a stock food in Europe than in the United States.

The important lesson taught by this paper is the danger of putting aside anything as a 'waste product' before it has been fully tried. In America as in the West Indies (in the old days of cotton cultivation) cotton-seed was accounted of no value. The trouble indeed was to get rid of it. All this is changed, and the cotton-seed with its by-products now forms an important crop in the United States, and gives employment to 'tens of thousands of labourers.'

Cotton-seed oil and oil cake are very largely imported into the West Indies for culinary and estate purposes. The cultivation of cotton is now being taken up in several of the islands and, if the seed is properly utilized, should lead to a substantial reduction in the importation of cotton-seed oil cake, and should aid in the securing of that measure of self-support which is essential to the welfare of the West Indies at the present time.

The following is an abstract of the paper :—

Cotton is distinguished from all other fibre plants in that the lint or fibre is attached to the seed. Owing to this fact

the seed of the cotton plant has always had to be gathered and handled by the cotton growers. The cotton gin was invented over 100 years ago, to separate the cotton from the, then worthless, seed. For nearly three-quarters of a century the seed was not made use of, and during that period it formed 'the most important contribution of the southern states to the world's great volume of waste.'

GROWTH OF THE INDUSTRY.

It is true that, as early as 1826, a mill was erected in the United States for extracting the oil from cotton seed, but so slowly did the industry progress that as recently as 1867 there were only four mills in actual operation in the United States. The poor keeping-qualities of cotton seed and its tendency to deteriorate when stored necessitate that the mills shall be in the neighbourhood where the cotton is grown. Between 1867 and 1897 nearly 300 mills were erected in the cotton regions of the United States, about one-third being in Texas, 'where not far from a like proportion of the cotton crop is now annually grown.'

USES OF COTTON SEED OIL.

The rapid growth of the industry was due to the industrial uses to which it was found the products of the cotton seed could be put. At first, cotton seed, although of intrinsic value, was put on the market as a substitute for, or an adulterant of, other already recognized articles; appearing for instance as 'pure olive oil.' It was found also that the oil mixed with a certain 'proportion of beef products made a good substitute for lard, and 'compound lard' was placed on the market as a substitute for hog lard. A considerable number of mixtures are now on the market, some containing pure lard, others not, and it is estimated that thirty per cent. of all the cotton seed oil made in the States is utilized in the manufacture of various substitutes for lard. 'In fact, the price of this oil is now largely regulated by the fluctuations in the price of lard.'

Other important uses are as a substitute for olive oil, in tinning sardines, etc., and as an ingredient of artificial butter. The lower grades of the oil are employed in the manufacture of soap, candles and glycerine, phonograph cylinders, etc. A bleached oil mixed with kerosene is used in miners' lamps. A deficiency in drying qualities prevents cotton-seed oil from competing with linseed oil for painting purposes, and a gum renders it undesirable as a lubricant.

BY-PRODUCTS FROM THE MANUFACTURE OF COTTON SEED OIL.

Short Lint: Upland cotton is the variety most extensively grown in the United States. Its seeds are covered with a coating of short lint, not removable by ordinary ginning. The first step at an oil mill is to clean and regin the seed. By this means some 30 ℔. of short lint is obtained from each ton of cotton seed.

'From the seed of a cotton crop of 10,000,000 bales there could thus be effected a saving, assuming that the entire crop were used, of about 300,000 bales of short lint, which at an average price of $15.00 a ton would amount to $4,500,000.'

Cotton Seed Hulls: The seed after having been reginned is run through machines which cut it to pieces and separate the hulls from the kernels or 'meats.' One ton of cotton seed yields nearly half a ton of hulls. These were formerly used for fuel, but they have been found to form, mixed with cotton seed meat, a superior food for cattle, and 'a steady demand now exists throughout the southern states for the entire supply.' The possible value of the hulls from a crop of 10,000,000 bales of cotton is estimated at $8,000,000.

Cotton Seed Oil Cake: The kernels constitute about half the weight of the seed, and yield about 30 per cent. of their weight of oil: 1,000 lb. of meats give on an average 300 lb. of oil or 40 gallons. The remainder, about 700 lb., is the well-known cotton seed oil cake, or after it is ground, cotton seed oil meal.

Cotton seed oil cake is a cattle food of very high value, containing on an average:—

Protein	43·26	per cent.
Nitrogen-free extract	22·31	,,
Fat	13·45	,,

Until within the last twenty years cotton seed oil meal and oil cake made in the United States have been largely exported, competing successfully in the European markets, as a cattle food, with the by-products of flax seed. The oil cake retained in the States was used as a fertilizer rather than as a food. 'Since the remarkable development of the cotton seed industry in Texas, cotton seed meal, mixed with cotton seed hulls and mill feeds, has been extensively adopted as a fattening food for cattle in the south-western states. Several hundred thousand head of cattle fattened upon this product are shipped thence each year, and its use as a feed has now become popularized to a limited extent throughout the entire south. The bulk of the cotton seed cake and meal manufactured in the United States is, however, still exported. . . . Practical economy has demonstrated that its full value is best realized in the cattle-feeding industry.'

At the low price of $20.00 a ton it is estimated that the cake or meal alone, from the cotton seed of a 10,000,000 bale cotton crop would be worth about $35,000,000.

PRESENT CONDITION OF THE INDUSTRY.

Within the last few years a great impetus has been given to the cotton seed industry, and since 1897, 200 additional mills have been erected in the cotton-growing states. Altogether there are now some 500 mills manufacturing oil. About one-third of the mills are situated in Texas, the most important cotton state. It is estimated that about 50 per cent. of the total crop of cotton seed raised in the United States is now manufactured in

the mills, of the remainder a large quantity is used for planting purposes—'the seed being sown by an extremely wasteful method, an inch apart in the rows, 90 per cent. of the growing plants to be afterwards "chopped" out in thinning. Also, the hereditary habit, among many cotton-growers, of carelessly handling this formerly waste product, together with its ready susceptibility to damage from rain or moisture, doubtless unfits considerable quantities yearly for manufacturing purposes.' Cotton seed oil, oil cake, and oil meal are in steady demand in both the United States and other countries. Cotton seed itself now commands high prices, and it is thought that under these influences the industry will be stimulated and soon result in the manufacture of every pound of cotton seed raised in the United States.

BENEFITS OF THE INDUSTRY.

The magnitude of the cotton seed industry may be gauged by the fact that a capital of over $100,000,000 has been invested in it. Employment is furnished to 'tens of thousands of labourers, almost exclusively of the resident negro race.' The foreign export trade of the southern states in oil and oil cake is worth $25,000,000 to $30,000,000 annually. In some states cattle feeding has received a great impetus, and is profitably carried out, on a large scale.

'In fact, the cotton seed industry, originally based on the chance discovery that a cumbersome and unsaleable by-product of the cotton belt was rich in oil, valuable chiefly for adulterative purposes, has now been transformed into a separate, distinct, organized business, and its manufactured products are sold extensively both in foreign and domestic markets on their own merits, for a great variety of purposes. The cotton seed crop is now an important entity in the agriculture of the country and has the distinction of being the most valuable oleaginous seed crop produced in the United States.'

STATISTICS OF INDUSTRY 1872-1901.

Year ending June 30.	Cotton seed crop.	Percentage of crop manufactured.	Oil produced.	Oil cake produced.
	Tons.		Gallons.	Tons.
1872 ...	1,317,637	4	2,108,000	18,400
1877 ...	1,968,590	5	3,937,000	34,400
1882 ...	2,455,221	12	11,785,000	103,100
1887 ...	3,018,360	23	27,769,000	243,000
1892 ...	4,273,734	25	42,737,000	374,000
1897 ...	4,070,100	40	65,122,000	569,800
1901 ...	4,830,280	50	96,605,600	845,299

The most interesting fact in the above table is the enormous increase in the percentage of the crop of cotton seed manufactured. From only 4 per cent. in 1872, it rose to 12 per cent. in 1882, 25 per cent. in 1892, and was 50 per cent. in 1901, the last year for which returns were available.

WORLD'S TRADE IN COTTON SEED OIL AND OIL CAKE.

The United States at the present time practically control the markets for cotton seed oil and oil cake. This is to a great extent due to the perishable nature of the cotton seed, necessitating the manufacture to be carried on in close proximity to where the cotton is grown. In the Egyptian and Sea Island varieties, the seed has not, as in Upland cotton, a coating of short lint left on it after ginning, and accordingly does not heat and deteriorate so rapidly. Egyptian cotton can be transported to some distance without damage, and a large industry is carried on in England at Hull, in the preparation of cotton seed oil, etc., from Egyptian cotton. A considerable manufacture is also carried on at Marseilles with Egyptian cotton seed. Altogether, however, England and France crush less than one-quarter the amount of seed crushed in the United States.

EXPORTS OF COTTON SEED OIL.

The average consumption of cotton seed oil in the United States of America is over 40,000,000 gallons annually. The home demands for this product have not increased rapidly of recent years, and the great increase in production mentioned above, has been absorbed chiefly by foreign demand. The home and export markets of the United States now share, very equally, the total production of oil.

Of the cotton seed oil exported, 85 to 90 per cent. goes to Europe; France and Holland being the largest consumers. France uses large quantities of low grade oil for refining, and soap manufacture, and high grade oil for various edible products, whilst Holland mainly imports high grades of summer yellow or 'butter' oil for the manufacture of artificial butter. A great increase in trade is reported with Mexico, and, to a less degree, with some of the South American republics.

'The total exports of cotton seed oil from the United States for the past three years have averaged, in cash value, $14,000,000.'

EXPORTS OF COTTON SEED OIL CAKE.

Cotton seed oil cake is consumed only to a limited extent in the United States, as compared with European countries. During the last two years only about one-quarter of the amount made has been retained for home use, and of this, perhaps one-half has been employed for mixing with fertilizers. Germany is the principal customer, followed by England whose finely-bred herds [of cattle] consume a larger quantity of cotton-seed cake and meal than do those of any other country on earth.' Germany, England, and Denmark take together about 85 per cent. of the cotton seed cake produced

in the United States, the total value of which for the past three years has been $11,000,000 per annum. The 'principal cis-Atlantic participants in the small balance of the trade are the Dominion of Canada and the West Indies'......'Notwithstanding the high prices that this product now commands, its greatest economic value would undoubtedly be realized by larger use as a domestic cattle food, thereby not only realizing its value as a feed, but also returning its rich fertilizing properties to the soil.'

THE ROOT-BORER OF SUGAR-CANE.

(*Diaprepes abbreviatus.*)

BY THE REV. N. B. WATSON,

Vicar of St. Martin's, Barbados.

During the discussion which followed his paper on 'The Lady-bird or Weevil borer of Sugar-cane,' read at the Agricultural Conference of 1902, (*West Indian Bulletin*, Vol. iii, page 91) Mr. H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S., in reply to the question 'whether the lady-bird borer is the white grub often found at the bottom of a cane stump when the canes are apparently withering,' said: 'I would like to point out that this grub is constantly confused with two others, known in the West Indies as the "hardback" and the "root-borer." The hardback grub is the grub of the common beetle *Ligyrus tumulosus*; it lives in the ground, feeding on decaying vegetable matter. The root-borer is the grub of an unknown beetle which also lives in the ground and feeds on the roots of cane, sweet potato and other plants, frequently boring into the underground base of the cane. It is distinct in structure and habits from the grub of the lady-bird, and never enters the cane except from below the surface of the ground.

'These three grubs are easily distinguished. The hardback grub has three pairs of legs; the weevil borer has no legs, but the hind end of the body is very much swollen into a sort of hump by which it pushes itself along its tunnel in the cane; the root-borer grub has no legs and no hump, but is thicker behind the head than at the end of the body.'

The characteristic features of these three grubs are well shown in the accompanying illustrations, drawn from nature, and placed at my disposal by the Imperial Department of Agriculture.

As the weevil of root-borer is now known, the object of this paper is to place before the reader such knowledge of its habits and life-history as will enable him to understand the conditions under which the several stages of its life are passed.

My attention was first called to the root-borer of sugar-cane on February 7, 1901, by Mr. W. D. Shepherd of Union Hall, St. Philip, whose keen interest in all that affects agriculture is well known. A large number of grubs were collected on February 11, but every effort to rear them to maturity failed. Pieces of sugar-cane, a foot in length, were divided longitudinally. and between these, in holes sufficiently large for their reception, the grubs were placed. After three days the pieces of cane were untied, and on separating the parts, it was found that the grubs had made but little, and in some instances, no attempt at tunnelling. Nine grubs were then removed and placed in a dish of earth in which five pieces of fresh cane had been inserted; in four days the cane was withdrawn for inspection, and each piece was found to have been attacked. Three pieces, attacked at the cut base, had evidently been quitted by the grubs for some time, as the gnawed parts were dry, and did not exceed $\frac{3}{16}$ inch in depth. The remaining pieces had been

FIG 1. GRUB OF THE ROOT-BORER.
(*Diaprepes abbreviatus.*)
Seen from the side. Magnified about twice.

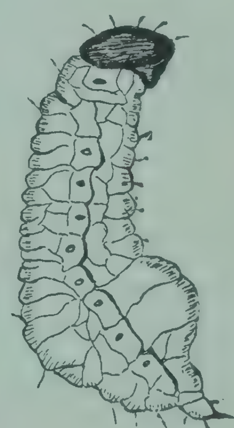

FIG 2. GRUB OF THE WEEVIL-BORER.
(*Sphenophorus sericeus.*)
Seen from the side. Magnified about three times.

FIG. 3. GRUB OF THE HARD-BACK.
(*Ligyrus tumulosus.*)
Seen from the side. Magnified about three times.

entered at the side, through the rind, to a depth of $\frac{3}{8}$ inch. Fresh cane was frequently inserted, but the grubs made no

further attempt at burrowing. This batch lived only twenty-one days.

Better results were however obtained in August 1902. From a field of sweet potatos at Harmony Lodge found to be infested with root-borer, thirteen well developed grubs were taken on July 12. These were placed in a vessel containing a mixture of earth and semi-decayed particles of cane trash, and regularly supplied with fresh stems and young tubers of the sweet potato. My immediate object being to discover the perfect insect, I refrained from disturbing the grubs for the purpose of observation, and am therefore unable to say when the period of pupation was entered on this occasion. At the expiration of twenty-one days (August 2) I was surprised to see clinging to the side of the vessel that contained the grubs, a weevil whose life-history I had already worked out in 1899 and 1900. Two days later, another weevil emerged. The earth was now removed from the vessel in order to obtain a pupa for preservation, but the remaining grubs had died, and were found in various stages of decomposition; one other had attempted to construct a nest wherein to undergo its metamorphosis, but perished in the effort.

It is entirely due to the success that attended my endeavours in 1899 and 1900, that I am able to record the length of time required for the grub to attain to maturity, as well as the number of days passed in the pupal period. All other data given in this paper are the results of subsequent observations.

Were it not necessary for the benefit of non-residents in Barbados, the only description required to identify the weevil of root-borer, would be the bare assertion that it is 'the lady-bird;' the large whitish weevil with stripes on its back: the plaything of our youth, which, when placed on the apex of our finger, would unfold its wings and fly away to the song—

> 'Lady-bird, Lady-bird, stay not a minute,
> Your home is on fire, your children are in it.'

THE EGG.

The eggs are opaque, cylindrical, oblong-ovate in outline, and measure nearly $\frac{1}{20}$ inch in length.

They are deposited in clusters on the upper surface of a leaf, to which they are firmly agglutinated, and as soon as a cluster has been laid, it is carefully concealed.

The number of eggs in a cluster may vary from eight to one hundred and thirty; they are laid in rows, and, owing to the process of laying being continuous, the eggs have often the appearance of being strung together.

Experiments have shown that the number of eggs in a cluster, and consequently, the number of clusters deposited by a single weevil, depend on the configuration and texture of the leaf on which they are laid. Clusters laid on soft flexible leaves invariably contain more eggs than those laid on hard inflexible leaves, or on leaves that are dry and crisp; soft

leaves being more advantageous for the concealment of the eggs.

The following account of four clusters laid by the same weevil, and given in the order in which they were laid, may be of some interest :—

(1) The first cluster was deposited (Aug. 17, 1902) on a leaf of the cephalic vine (*Argyreia speciosa*. Lour.) by a weevil that had passed the pairing period caged. The lobes of this cordate leaf are very large, and if the creeper is sheltered, leaves are frequently found with their lobes overlapping. Between two such overlapping lobes, and on the upper surface of the lower lobe, 127 eggs were deposited, covering an area of $\frac{7}{10}$ by $\frac{1}{5}$ inch, and placed in rows side by side. Several rows contained two layers of eggs. When the weevil withdrew the pressure of the upper lobe was sufficient to cause it to adhere to the eggs, and effect their concealment. This cluster was laid at 3 p.m. At 5 p.m. the weevil was removed to the breeding-cage, and supplied with portions of both green and dried leaves of sugar-cane, Guinea corn, sweet potato, and bonavist (*Dolichos Lablab.*)

(2) The second and third clusters were deposited before 4 p.m. on the succeeding day. One cluster was placed on the withered blade of the Guinea corn and contained ten eggs. The spot selected was half an inch from the midrib. This cluster was covered with a piece of the green bonavist leaf, its margins being firmly pressed and secured to the surface of the corn-blade. The other cluster was laid on the withered potato leaf, and contained eight eggs; a piece of the same leaf was cut off and used as a cap for covering the eggs.

(3) The fourth cluster was laid before noon on the third day (Aug. 19) on another leaf of the cephalic vine, on which the weevil had been placed the previous evening, and secured by drawing a bag, made of mosquito net, over the leaf, and fastening it to the stem. As the lobes of this leaf did not overlap, the eggs, 110 in number, were deposited midway on the leaf, between the midrib and the margin. They were laid in three rows, placed side by side. The rows numbered thirty-two, thirty-eight, and thirty respectively, and covered an area of $1\frac{3}{5}$ by $\frac{1}{10}$ inches. The surface of the leaf was then drawn together over the eggs, to which it firmly adhered and formed a tuck for their concealment. Two days after the last batch was laid the weevil died, having laid altogether 255 eggs.

The freshly-laid eggs are white, and remain so until the fourth day, when the end enclosing the larval head becomes slightly tinged with yellowish-brown. On the sixth day the enclosed larva can be seen, by the aid of a lens, lying full-length in the egg. In ten days the eggs hatch, and the larvae emerge by boring a way through the egg and leaf.

THE LARVA.

On emerging from the egg, the larvae fall to the ground and wander off in all directions on the surface of the soil, until

a suitable spot is reached, when they burrow and disappear.

As soon as the grubs have burrowed, they seem to attack the roots of almost any plant they may happen to meet. Their first attack on the sugar-cane appears to be made on the soft extremities of the adventitious roots. The underground root stock is not attacked, so far as I am aware, until the grub has attained to the size of from $\frac{3}{16}$ inch to $\frac{1}{4}$ inch. The first effects of the attack of young grubs on the sugar-cane are hardly noticeable; the narrow tunnel, severing only a small portion of vascular tissues, affects the cane so little that withering, hardly, if ever, is observed. Stunted growth, and symptoms similar to those following fungoid infection, are the first signs of an attack of the small grubs of the root-borer.

As the grub advances in growth, the effects of its attack are more apparent; the increased size of its tunnel, necessitating the severance of a large portion of the fibro-vascular bundles, cuts off the flow of nourishment, and the cane, as a natural consequence withers and dies.

On entering the most vital part of the cane, some nine to eleven inches underground, the grub bores its way inwards and then upwards until within six or seven inches of the surface, when it quits its victim for a fresh one by the same hole which it had made for its ingress. *One grub is often responsible for the death of a whole stool of canes.* Owing to the fact that the grubs' life is not commensurate with that of the sugar-cane, and that the grubs do not feed on decaying vegetable matter, the close of the reaping-season would be a bar to their further development, were it not that they are capable of adapting themselves to other fare, and a less sheltered abode, than the sugar-cane offers. An illustration of this might have been seen in the large percentage of dead and dying plants, so noticeable in the fields of ground-nut and sweet potato planted during the first week of June 1902. An examination made at the time disclosed that in every instance the underground stem of the dead plant had been attacked at its lowest extremity and eaten from below upwards. Only the inner and more succulent part of the root was devoured, the cuticle being pushed aside until the thicker parts were reached, when the grub would use it as a means of shelter and concealment. The first sign that a sweet potato cutting has been attacked is its drooping with a slightly withered appearance of the leaves. By carefully removing the soil from around the stem of such a plant, the grub will be found when the first adventitious roots are reached. Below that point no more of the stem will be found, so that although but slightly withered, the plant will, in reality, be quite dead. Not more than one grub is ever found at the same slip. Plants that are quite dry, or much withered, yield no grubs at all, but if the next or leeward slip is searched the grub will, most likely, be found to have already turned its attention to that. It is worthy of note that fields not under cane in 1901, and at some distance from fields that had been, were practically free from the ravages of root-borer during the months of June, July and August 1902. Grubs found in June were well advanced and the brood from eggs laid in August or September 1901.

The numerical increase of root-borer is evidently due to the result of planting in infested fields the particular kind of food which enables it to continue and to complete its larval life.

Description of Larva: The newly hatched larva is $\frac{1}{18}$ inch in length. The colour of its body is a light tinge ofyellowish-brown; the head, pronotum, and mandibles being a shade darker. Viewed laterally, and when at rest, the body is dorsally curled in the shape of a crescent (see Fig. 1.) The head and segments of the body are sparsely furnished with uniform rows of setae, those on the dorsal surface of the three last abdominal segments being the longest, while those on the ventral surface are shorter and inclined backwards. The setae appear to be less numerous as the larva develops, especially on the dorsal surface. Those on the ventral surface remain intact, and probably assist the legless grub in effecting its movements.

Two longitudinal rows of large wart-like tubercles border the side from the mesothoracic to the seventh abdominal segment. The dorso-lateral tubercles are the largest, and are either corniform or dentiform. The lower, or ventro-lateral row are small, roundish, and more uniform in shape and size. In the adult, the head is subrotund, large, flavo-fuscous in colour, and marked with two divergent light stripes, running from the pronotum to the front. The mandibles are powerful, flavo-piceous, and deeply excavate at their extremities. The body of the larva is robust, the spiracles are circled with black, and occur on the prothorax (apparently), and first eight abdominal segments. Those on the prothorax are the largest, and ovate in outline, the remaining ones are round, and gradually decrease in size, the posterior pair being the smallest. The mature larva is from $\frac{7}{8}$ to 1 inch in length, $\frac{5}{16}$ to $\frac{3}{8}$ inch in width across the dorsal surface, and its thickness, from the ventral to the dorsal side across the costa is $\frac{5}{16}$ inch.

The legless grub is able to effect its motion by the alternate contractions and elongations of the segments, aided by the push of the extremity of the body, and by its powerful mandibles, with which it takes hold of the sides of its burrow, and draws itself along. The abdominal setules, and the dorso-lateral tubercles also appear to aid the larva in its movements. When fully mature, in 300 to 312 days, the larva ceases to feed, and burrows in quest of some suitable place for undergoing its metamorphosis. The style of cradle constructed, in which the period of pupation is to be passed, depends on the material procurable. Pupae found in the buried stumps of the cane are mostly inclosed in a cocoon similar to, but rougher than that constructed by the lady-bird borer (*Spenophorus sericeus*). Others are found inclosed in a rough nest composed of particles of decaying cane leaf, while the majority content themselves with an earthen cell, similar to that of the hardback (*Ligyrus tumulosus*), at a depth of six to eight inches below the surface of the ground.

THE PUPA.

The pupa, which somewhat resembles the perfect insect, is at first white. On approaching maturity the dorsal surface of

the head and prothorax become light amber in colour, while the wing-cases, legs, and abdominal segments are light yellow. The pupae are inactive and exhibit no motion when disturbed. The period of pupation is fifteen days.

THE IMAGO.

On emerging from the pupal integument, the imago is soft, and of a brownish-white colour. In two or three days the hardening process is completed, and the permanent colours are developed. The weevil now crawls from its pupal grave, and after a short exposure to the air, flies off to some sheltered locality. Cracks and crevices on the lee-side of an old wall may offer a temporary hiding place, but the weevil's favourite haunt is among the foliage of some leafy, low-growing bush.

The pairing season, which is entered on the third or fourth day after emergence, lasts from seven to eight days. This period is spent in long and frequent coition, several hours daily being spent by the male, in constant motion, clinging to the back of his partner. The cordia (*C. Sebestena*) on account of the inflexibleness of its branches during high-winds, and the close contact of its large, crisp, and introverted leaves, is the weevil's favourite resort during this period. As many as five pairs of weevils have been taken from among the leaves of one branch. Some care must be observed in searching for weevils—the leaves beginning at the apex of the branch should be gently raised, otherwise the weevils will fold their legs, fall to the ground, and disappear among the grass and under-growth. Male weevils do not appear to survive the pairing period for more than a day or two; after the labours of coition are ended they become exhausted and die. The females, after a few days, begin to lay their eggs. When a suitable leaf is found, the surface of the spot on which the eggs are to be deposited is first roughened, the weevil, using her curious and powerful mandibles for the purpose, scrapes off the outer layer of the epidermis. She now deposits the eggs in rows, moving slowly forward and backward until the batch is laid. A viscous fluid is deposited with the eggs which agglutinates them to the leaf, and secures the edges of the nest when brought together for the concealment of the eggs. One female lays from 240 to 270 eggs, and probably dies in one or two days after the last batch is deposited.

Description of Weevil: Elongate, pyriform or cymbiform, dorsally convex. Elytra, sides and abdomen thickly clothed with exiguous appressed pruinose scales, which are easily abraded. Elytra much wider than, and almost three times the length of the prothorax, abruptly declivous behind, subparallel from a little below the base to a little beyond the metathorax, and rapidly narrowing thence to the apex, the apices acuminate; greenish white, with testaceous sutural and marginal carina, and eight testaceous costae, abbreviated behind, and sparsely clothed with shining glaucous scales—two springing from the humeral angle of each elytron, and two on the disc, the interstices white, margined with a single row of regular and very fine punctures; humeri carinated, prominent, and rounded;

scutellum—minute, convex, round; prothorax longer than broad, slightly margined and sinuate at the base, the sides abruptly declivous, rounded, and slightly swollen midway above the pro-leg, transversely convex, twice as wide at base as apex, coarsely and irregularly rugate, with slightly shining iridescent metallic glaucous scales, interstices irregular and pruinose; head curvate, as long as thorax but narrower, the base somewhat wider than apex which is truncate; bisulcate, with a longitudinal median carina, springing from interocular space; sides with antennal fossettes prolonged into a channel that terminates below the orbits; eyes round, prominent, widely separated, black, finely granulated; antennae moderately long, extending to a little beyond the hind angles of the prothorax, elbowed at second joint, joint one, the longest, as long as the head; the third twice as long as the second, which is inserted at external angle of the first; the second longer than the fourth which is itself slightly longer than the fifth; fifth to the eighth joints short, subequal, ninth to the twelfth forming a well defined club. Epistoma divaricate, and fringed with stiff setae; mandibles robust, deeply excavate, pointed at the tips and outer angles; labium operculiform. Legs moderately long, femora strongly clavate, the tibiae sparsely pubescent, and bowed inwards towards the apex, tarsi, thickly clothed with fine, semi-erect hairs, pulvilli ovate, fulvous; coxae of fore-legs mammilloid, contiguous, occupying almost the entire surface of prosternum, those of mesosternum less swollen and separated by a median ridge. Length, male $\frac{5}{8}$ inch; female $\frac{3}{4}$ inch.

SUMMARY OF LIFE-HISTORY.

Egg.	10 days.	Deposited on upper surface of a leaf during August and September.
Larva.	312 ,,	Feeding on roots or underground base of sugar-cane, sweet potato and *Sorghum.*
Pupa.	15 ,,	Later part of July, enclosed either in roughly constructed cocoon of decaying trash or in an earth-cell similar to that of the hardback beetle.
Imago to pairing period	3 ,,	
,, pairing period	8 ,,	Between the leaves of *Cordia* and other large-leafed plants.
,, close of pairing period to egg laying	4 ,,	
,, Egg laying	3 ,,	
,, After egg laying	2 ,,	
Total life	357 ,,	

REMEDIAL MEASURES.

The root-borer may be regarded as having been a pest of comparative insignificance until within the last two or three years. Its insidious attack on the sugar-cane and sweet potato prior to 1901 was probably unobserved on account of its small numbers: but since 1901 its numbers have increased to such great extent that its ravages, each year, are more and more apparent.

It has already been suggested in this paper that the increase of root-borer is the result of planting in infested fields that food which enables it to complete its larval life. This, however, is not the primary cause. The abnormal increase of this pest, and indeed of all the insect pests in Barbados, can be traced to another source, and that the mungoose, which, having signally failed in its mission of exterminating the rats, has certainly succeeded in destroying most of those reptiles and birds that kept our insect pests in subjection. In the egg, larval and pupal stages *Diaprepes abbreviatus* is, as far as I know, free from parasitical or other attack, but on emerging from the ground as a perfect insect, it would be subject to the attack of any predaceous insectivorous animal, and as elytra of this weevil have been found in the stomach of the ground lizard

Name of Pest.	Approximate no. of eggs laid by one female.	Duration of life (in days) from egg to death of Imago.	No. of possible generations during one year.	Natural enemies of		
				Egg.	Larva.	Imago.
(1) Moth-borer. (*Diatraea saccharalis.*)	150	42—50	7	*Trichogramma pretiosa.*	*Cordyceps* (Isaria) *Barberi.*	Cane Sparrow Lizards.
(2) Lady-bird borer. (*Sphenophorus sericeus.*)	250 (?)	100—120	3	...	...	Ground lizard. Toad.
(3) The root-borer (*Diaprepes abbreviatus.*)	357	350—357	1	...	Ants, occasionally. Centipede.	Ground lizard. Toad.

(*Centropyx intermedius*), it is reasonable to suppose that this, now almost exterminated, reptile was one of those checks provided by nature for its subjugation. The increase of root-borer, like that of the other insect pests of Barbados, has been gradual, and in proportion to the decrease of natural enemies. That the root-borer has taken a longer time to increase than either the moth-borer (*Diatraea saccharalis*), or the lady-bird borer (*Sphenophorus sericeus*), is undeniable, but easily accounted for, as a glance at the table on the previous page will show.

Remedial measures for the check of root-borer are both simple and inexpensive.

Bearing in mind that its favourite food plants are sugar-cane, sweet potato (*Ipomoea Batatas*), imphee (*Sorghum saccharatum*), ground-nut (*Arachis hypogaea*) and Guinea corn (*Sorghum vulgare*),—and that neither of these are commensurate with its larval life—it will be seen that, unless either of the above plants are grown in succession. the grubs will perish for lack of sustenance. The life of the sugar-cane would be commensurate with that of the grub were it not for the fact that egg-laying occurs in August and September, when the canes are already well advanced. For this reason canes should never immediately succeed sweet potatos or imphee, nor should either of these immediately succeed canes—unless lime has been forked into the field. Apart from its usefulness as an insecticide, 'lime promotes the decay of vegetable matter—giving rise, by the decomposition that ensues, to the production of carbonic acid. It also destroys certain harmful compounds of iron, and serves to liberate potash from the insoluble silicates of that base contained in clay soils.'

The sweet potato field may be regarded as the nursery of root-borer. The soft leaves of the potato vine offer every facility for nesting the eggs, while the tender sprouts supply the young larvae with their choicest food. It is therefore unwise to plant canes in a field that contained sweet potatos during the egg-laying period (August and September) unless some means have been employed to destroy the grubs, for even if that crop is reaped by the end of October, the sprouts from small tubers that are inevitably left in the field would be sufficient to keep many of the young grubs alive until the canes are planted. Should, however, this source of their food supply be cut off, the grubs will migrate to the adjoining cane field, hence it is that an attack on old canes invariably occurs on the outer rows. Another check to the increase of root-borer would be the removal of stumps from infected fields as soon as the canes are reaped. When stumps are turned up and allowed to remain scattered over the field—or when packed on the hedge-row—the grubs quit them and burrow in quest of moisture and fresher food. Grubs will live without food from twelve to fifteen days in moist earth; in dry earth they rarely live longer than five days. In addition to plant crops, the grub of root-borer has been taken from the main root of young 'bread and cheese,' or moabite (*Pithecolobium Unguis-cati*) and from among the roots of young palms.

The following is a list of those cultivated plants that do not appear to be subject to the attack of the grub of the root-borer :—

Ochro	...	(*Hibiscus esculentus.*)
Cassava ...	...	(*Manihot utilissima.*)
Yams and Eddoes	...	(*Dioscorea*, and *Colocasia.*)
Woolly Pyrol ...	...	(*Phaseolus Mungo.*)
Pigeon pea	...	(*Cajanus indicus.*)
Bonavist	...	(*Dolichos Lablab.*)
Rouncival pea ...	...	(*Vigna glabra.*)
Bean ...	...	(*Phaseolus lunatus.*)

The above suggestions aim principally at checking the increase of root-borer by cutting off its food supply either in the earlier stages of its growth, or during the later period of its larval existence. The use of lime has also been suggested as a direct means for the actual destruction of this pest; but, after all, its complete control must depend on that readjustment of our fauna, which will at once displace the exotic mungoose, and restore to the predaceous reptiles and insectivorous birds of Barbados that place and protection which nature assigned them.

[NOTE ADDED.]

In Bulletin No. 30 New Series of the U.S. Department of Agriculture, Division of Entomology, p. 97, it is noted that *Diaprepes abbreviatus* occurs in Porto Rico. We quote the following passage :—

'Writing July 30, 1900, Mr J. W. Van Leenhoff sent specimens of the snout beetle, *Diaprepes abbreviatus*, with the information that they were met with in considerable numbers attacking the young plants of guava grown for shade, and according to the report were attacking also young coffee plants. The young plants of the guava were eaten bare of their leaves. They were kept in subjection by hand picking, the beetles as fast as caught being placed in a wide-mouthed bottle and afterwards burned.'

It is important to notice that in this instance it is the adult beetle and not the grub which is reported as doing damage. (Ed. *W.I.B.*)

DISEASE-RESISTING VARIETIES OF PLANTS.

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It is a fact well known to agriculturists that, whenever a disease attacks cultivated crops, some varieties of the cultivated plant are found to be less liable to the disease than others. It becomes therefore one of the chief functions of the scientific agriculturist to discover and to select such disease-resisting varieties and to recommend them to the practical gardener, farmer or planter for cultivation.

The discovery of disease-resisting varieties might at first seem a simple matter, but there are many difficulties to contend with. In the first place these hardy varieties are usually inferior, either in the quantity or in the quality of their produce, to the less resistant forms, and the practical agriculturist will often prefer to take the risk of losing the greater part of his crop by disease, than the certainty of having a smaller or otherwise inferior crop. Then again the plant-breeder has to deal with the fact that, if cultivated plants can vary, and vary in such a way as to become more resistant to certain animal or vegetable parasites, these parasites can also vary, and vary in such a way that they become capable of attacking plants which were previously immune to them, so that after our disease-resisting variety has been in cultivation for some years, it is found to be just as liable to disease as any other variety. That a fungus can vary and adapt itself to different hosts is shown by the behaviour of the wheat rust (*Puccinia graminis*). Eriksson demonstrated that this fungus is split up into several special varieties or races, 'each of which grows well on some grasses but refuses to infect others. Thus the variety which infects wheat refuses to infect barley or oats, while that variety which grows on rye will not take on wheat and so forth. Now it is important to notice that these specialized races are indistinguishable one from another by their visible microscopic characters : they are all botanically of one species (*Puccinia graminis.*)[1]' That is, this fungus is adapting itself to live on special kinds of grasses, and many other fungi are doing the same thing. It is therefore easily conceivable that a fungus will gradually adapt itself to living on a variety which at present it is unable to infect.

Another difficulty in breeding disease-resisting varieties is the fact that a variety which has proved itself resistant in one locality may succumb very easily in another. Experiments to test the resistant powers of any variety must therefore be conducted in every locality in which it is proposed to introduce that variety.

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1 H. Marshall Ward. *Disease in Plants*. p. 176.

The agriculturist has two chief methods of obtaining disease-resistant varieties :—

(1) The introduction of hardy varieties from other localities.

(2) The breeding of new varieties either by simple selection or by hybridization.

Very often the two processes are combined, more especially the introduction of new races and hybridization. A new variety is introduced and it is found that, though resistant to disease, it is inferior in its produce or is not so resistant to unfavourable climatic conditions as the native varieties. It is then crossed with one or more of these varieties in the hope of obtaining a hybrid form combining the good qualities of the native and foreign parents.

The breeding of disease-resistant varieties by selection is (on paper) a simple matter. A crop is sown in a locality known to be infested with the disease, most of the plants will probably be attacked, but some few will, perhaps, not be attacked, or only slightly. Seeds are taken from these plants and are sown. Probably most of the plants so obtained will again be attacked, but some proportion, possibly in this case a larger one, will escape. The seeds from the plants not attacked are again selected and used for planting. This selection is continued, for generation after generation, until practically the whole crop is free from disease at a time and in a locality where other varieties suffer badly. Of course the breeder may find that while he has been breeding a disease-resistant variety of his cultivated plant he has, unconsciously, been breeding at the same time a specially virulent variety of the parasitic insect or fungus, so that all his efforts are of no avail. Again, he may find that his special variety is perfectly useless outside the locality in which it has been raised, and he must remember that his variety must not be inferior in quantity or quality of produce to the best varieties usually cultivated. However, the plant-breeder is prepared for these difficulties; he knows that they have been overcome before, and he is quite content to work for years, knowing that in the end some measure, at least, of success must be his.

Grafting may perhaps be mentioned here as it is a method of obtaining disease-resistant individuals though not varieties. Many of the best varieties of fruit trees for instance, are so subject to insect and fungoid attack that they cannot be raised from cuttings, they are then reproduced by grafting them on to a stock of a hardier variety. For example, oranges are greatly subject to aroot disease known as *mal-di-gomma :* to meet this the sweet orange is grafted on to the inferior but much hardier sour orange stock.

Very little is known as to how and why certain varieties are more resistant to disease than others.[1] In some cases the reason can be guessed at with some certainty, but in most nothing whatever is known. In some cases immunity is

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1. H. Marshall Ward. *Disease in Plants.*

secured by the variety becoming mature at a time of the year when the fungus or insect is not virulent, for instance the potato disease in England is most destructive during the hot weather of July, it follows that a variety of potato which matures its tubers before July, will be, to a great extent at least, immune to the attacks of this fungus. Again it has been suggested that the comparative immunity to rust of certain Australian varieties of wheat is due to a greater thickness of the cuticle of the leaves, and to the smaller number of stomata on a square inch of leaf surface. Thick-skinned varieties of potatos, etc., will naturally be less liable to attack from parasites present in the soil. Thick-skinned apples, tomatos, etc , will be less liable to attack from fungi which gain access through bruises and other wounds and will therefore store better than thin-skinned forms. In other cases increased resistance is stated to be due to a deeper rooting habit.

The following is an incomplete account of what has been and is being done in various parts of the world to introduce and raise disease-resistant varieties of cultivated plants.

GRAPE VINE.

The two most destructive diseases of the grape vine are the *Phylloxera*, a root-louse which attacks the roots of European vines and almost destroyed the vineyards of France ; and the downy mildew (*Plasmopora viticola*), a fungus which attacks the leaves. It was found that certain American vines, such as *Vitis rupestris* and *V. riparia* are highly resistant to the attacks of *Phylloxera*. Unfortunately, as is so often the case, the wine made from these vines is inferior in quality and flavour to that made from the European vine (*Vitis vinifera*). This difficulty was met, in the first place, by grafting European vines on American stocks; by this means the roots were not attacked by the *Phylloxera*, while the grapes were those of the European species. Further, a number of scientific agriculturists endeavoured to raise a new variety of vine which should combine the disease-resistant properties of the American vine with the superior produce of the European. *Millardet* [1] after very numerous experiments in hybridizing European with American vines finally succeeded in raising hybrids with roots proof against *Phylloxera*, leaves proof against the downy mildew, and grapes which produce wine of the desired flavour.

WHEAT.

Wheat is the chief cereal crop of Europe, and of some parts of the United States and Australia. In all these countries it suffers damage by the rust fungus (*Puccinia*). The damage done is sometimes enormous, thus it was calculated [2] that in 1891, the loss, in Prussia alone, by the rusts of wheat,

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1. Millardet. 'Notes sur le vignes Amèricaines.' Ser. III *Mem. de la Soc. des Sciences de Bordeaux*, 1891 ; *Journ. d'agriculture pratique* 1892 ; *Comptes Rendus*, 1894.

2. *Zeitschrift für Pflanzenkrankheiten*, 1893.

oats and rye, amounted to £20,628,147, or nearly one-third of the total value of the crop. Moreover it has not been found possible to devise any remedial methods to combat the disease.

In Europe, the United States and Australia experiments have been conducted for many years with a view to raising varieties of wheat resistant to rust.

In Europe the most noteworthy results are those of Eriksson[1] in Sweden. After carrying on cultivation of wheat for a number of years Eriksson obtained varieties which he proved to be resistant to rust. It is interesting to note that when these varieties were introduced into Australia they were found to be liable to rust; here, however, the matter is complicated by the fact that the rust most prevalent in Sweden is the golden rust *(Puccinia glumarum)*, while those most prevalent in Australia are *Puccinia graminis* and *P. dispersa*.

In Australia[2] experiments have been and are being carried on under the Departments of Agriculture of Victoria,[3] New South Wales,[4] Queensland and South Australia with a view to raising new, rust-resistant varieties of wheat.

At a conference of delegates from the Australian wheat-growing colonies a committee was appointed to draw up a series of resolutions with regard to wheat rust.[5] Resolution (4) submitted to the conference was as follows :—

'This Conference, fully believing that no such cereal as rust-proof wheat has yet been discovered, but that—as shown from experiments already carried out by importing different varieties from countries outside the Australian colonies and by carefully selecting within the colonies—certain kinds have proved to be constitutionally able to resist to a considerable extent the ravages of this pest, recommends a continuation of this work of selection and importation, with a view to securing varieties most likely to prove remunerative to the wheat farmers of the various colonies.

'And, it having been found, from evidence submitted to this Conference, that certain varieties of wheat believed to be rust-resisting when grown in one locality have succumbed to the pest when grown in another locality, this Conference considers that it would not be justified in specifying any particular varieties as possessing rust-resisting qualities under all conditions.'

The experiments have been continued, and by importation, selection and crossing, several new varieties of wheat have been obtained which are, at the same time, rust-resistant and

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1. Eriksson. *Zeitschrift für Pflanzenkrankheiten*, 1895.

2. 'Rust in wheat.' *Minutes of Proceedings at a Conference of Delegates from Victoria, South Australia, New South Wales and Queensland, Melbourne*, 1890.

3. *Guides to Growers, No. 35*, Rust in Wheat. Experiments 1894 to 1896-7. Department of Agriculture, Victoria.

4. Farrer. The making and improvement of wheat for Australian colonies *Agricultural Gazette of New South Wales*, Vol. ix, 1898.

5. 'Rust in Wheat.' *Ibid*, p. 41.

produce good crops. For instance, Mr. McAlpine in the account of the experiments at Port Fairy, in Victoria, in 1897-8, while pointing out that there is no such a thing as a rust-proof wheat, says that 'there are rust-resistant wheats which can so constitutionally resist the rust under certain proved conditions that in a rusty year the yield will not be seriously affected.'

To take examples from among selected wheat grown on a large scale; 'Ward's Prolific is a good milling, good-yielding, and rust-resisting wheat, having stood the test for eight years. It also holds the grain well, and is comparatively early.' Another form, which is a composite hybrid raised by Mr. Farrer of New South Wales, is reported as yielding well (42 bushels per acre), and promising to be a good milling wheat and not badly attacked by rust.[2]

In the United States the Division of Vegetable Physiology and Pathology has for many years been investigating many problems connected with wheat production, among them being the question of the raising of disease-resistant varieties. In *Bulletin No. 24* of this Division Mr. Carleton[3] gives an account of the work already done and that being carried on. He describes how the chief varieties of American wheat have been produced, some by introduction, others by pure selection, and others again by simple or composite hybridization. He gives an account of the work done in hybridizing by the Gartons in England and by Mr. Farrer in New South Wales to a great extent with the object of securing disease-resisting varieties, and suggests the lines upon which experiments in wheat raising to meet the varied requirements of the different wheat districts, should be carried on.

In England Messrs. Garton of Newton-le-Willows have for years been carrying on experiments in hybridization, often of a most complex character. As a result numerous varieties of wheat have been obtained which are not only rust-resisting but also possess many other desirable characteristics.

COTTON.

In the United States, the 'wilt' disease of cotton is known to occur in South Carolina, Alabama, Georgia, Arkansas and Florida; the loss caused by the disease has been very great and fears were felt that it might ultimately spread to such an extent as possibly to threaten the life of the industry. The study of this disease and its control were undertaken by Mr. W. A. Orton, of the Division of Vegetable Physiology and

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1. *Guide to Growers, No. 37.* Wheat experiments 1897-8; Department of Agriculture, Victoria.

2. See also *Agricultural Ledger*, 1897, No. 16, 'Rust in wheat in the Australian Colonies.' (Calcutta) for a precis of the literature of the Australian Inter-Colonial Wheat Conference.

3. 'The Basis for the Improvement of American Wheats' by Mark Alfred Carleton, *Bulletin 24, U.S. Department of Agriculture, Division of Vegetable Physiology and Pathology*, 1900.

Pathology of the U. S. Department of Agriculture.[1] Fungicides applied to the soil proved of no avail, and though hygienic treatment by rotation of crops, removal of diseased plants, etc. was recommended, the most encouraging results were those obtained in endeavouring to find a race of cotton resistant to the disease. In an experiment to test the disease-resisting power of various races, twenty varieties of cotton were planted in a field that was thoroughly infested with the wilt disease, their comparative resistance was determined by counting the number of plants remaining healthy, those partially diseased, and those killed. The following table gives the result of the experiment; the figures give the comparative resistance of the different races on a scale of one thousand:—

Yannovitch	565	Brady	127
Mitaffifi	559	Cook's Long Staple	124
Abassi	479	Excelsior	104
Jackson	453	Drake	90
Sea Island	233	Jones	88
Eldorado	227	King	83
Texas Wood	162	Peterkin	71
Doughty	148	Truitt	71
Hawkins' Prolific	142	Russell	55

This experiment shows that while none of the varieties in cultivation are disease-proof, there are a few which are disease-resistant. The Yannovitch and Mitaffifi varieties are both Egyptian races and their resistance is an example of the advantages obtained by the introduction of varieties from other countries; the Yannovitch is said to be a hybrid between Sea Island and Egyptian cotton. It is an interesting fact that it was found that the wilt fungus (*Neocosmospora vasinfecta*) was able to infect the roots of these resistant varieties, but was unable to enter the main root system.

The raising of new resistant varieties is only being begun, but certain trials are worthy of mention. Mr. Elias L. Rivers, of James Island, S.C., selected a healthy plant of Sea Island cotton growing in a badly infected field in 1899. He sowed the seed from this plant in a single row through a field that had been infested with the wilt disease for several years. The other rows were planted with seed from his main crop, grown on non-infected land. Of the ordinary cotton 95 per cent. of the plants were killed, while in the row planted with seed from the resistant plant not one plant was killed by the wilt disease. The quality of the lint was good though not equal to that of the crop from which the selection was made. It is hoped that by continuous crossing and selection the quality of the cotton will be improved without loss of resistance to the wilt disease.

Selection and crossing both of various native varieties, and of these with the imported Egyptian varieties, are being carried on 'with a view both to resistance and to quality of staple.'

In Egypt also the cotton crop has suffered greatly from

1. 'The Wilt Disease of Cotton and its Control' by W. A. Orton. *Bulletin 27. Division of Vegetable Physiology and Pathology.* U.S. Department of Agriculture.

fungoid attack.[1] The chief destruction was due in this case to the 'sore-shin' fungus (*Pythium*), the wilt fungus was also present but generally followed the attack of the other fungus. Professor Fletcher has studied the disease-resisting qualities of the chief Egyptian varieties of cotton and comes to the conclusion that 'Abassi seems to suffer most from the disease and Mitaffifi and Yannovitch least.' It is interesting to note that the varieties which were proved in America to be most resistant to the wilt disease, are not only practically immune to this in Egypt but are also the most resistant to the 'sore-shin' disease.

COFFEE.

In the East Indies some years ago the Arabian coffee (*Coffea arabica*) was so badly attacked by a fungus (*Hemileia*) that the planters were practically forced to give up the cultivation of this variety. It has been largely replaced by the Liberian coffee (*C. liberica*) a species which is hardier, larger, and more productive than *C. arabica* and which is more resistant to *Hemileia*, but which unfortunately produces coffee of inferior flavour.

Numerous experiments have been made with a view to raising new varieties. Finally it is stated[2] that M. Henri Manes has succeeded in obtaining a hybrid between *Coffea arabica* and *C. liberica* which combines the good qualities of both parents, more especially the fine flavour of Arabian coffee with the resistance to disease of the Liberian.

Experiments with other species of coffee, for instance, *C. stenophylla* and *C. robusta* have also been tried.

The Arabian coffee in Java is also more susceptible to the attacks of a root-knot or nematode worm than the Liberian, and it has been suggested by Zimmerman[3] and others that the disease may be controlled by grafting Arabian coffee upon the more resistant Liberian stock.

POTATO.

In the British Isles and on the Continent of Europe, the potato crop is an important one in some districts. During the years 1845-50 a disease due to a fungus (*Phytophthora infestans*) broke out and did an enormous amount of damage to the crop. Various preventive and remedial measures were tried, many with good results. The best results, however, were again obtained by the breeding of hardy varieties and numbers of these are now advertised every year in the seed

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1. Fletcher—'Notes on Two Diseases of Cotton.' *Journal of the Khedivial Agricultural Society and the School of Agriculture.* Nov. and Dec. 1902, Vol iv. No. 6.

2. Bordage 'Sur un Hybride de Caféier Libéria et de Caféier d'Arabie. *Rev. des Cult. Col. T.* viii.

3. Zimmerman, A. Het Groepsgewijs afsterfen der Koffie heesters in gesloten plantsoenen. *Teysmannia*, 1897; also De Nematoden der Koffiewortels. I. *Mededeelingen int's Lands Plantentuin*, 1898, No. 27.

catalogues. The disease though it appears every year is kept well in hand.

In India the potato is cultivated to some extent in the Bombay Presidency and in some other provinces. In 1891[1] the crop was badly attacked by a fungus which 'caused heavy loss to the cultivators and a marked deterioration of quality in the potatos sold for consumption.' The fungus was identified as a species of *Phytophthora.* It was found that the disease could be largely kept in check by the use of fungicides, but most reliance was placed on the distribution of 'seed' of varieties which were proved to be disease-resistant. These varieties were a number of forms imported from England. So successful were these races in resisting the disease that experiments carried out with caustic lime and soot and with different methods of cultivation were rendered inconclusive, as none of the plants were attacked.

COW PEA.

The cow pea (*Vigna Catjang*) is an important crop, not only in the West Indies, but also in some of the southern United States where it is the principal leguminous crop. It is grown there for hay, for forage, for seed, and for its value as a fertilizer, and no other crop is known which could fully take its place.

Recently a wilt disease[2] has appeared in certain of the states which has caused great loss. The disease is caused by a fungus, *(Neocosmospora vasinfecta,* var. *tracheiphila,)* which attacks the smaller roots in the first place, and spreads through the vessels of the stem, till sometimes it is found even in the smaller branches and in the leaves. As is the case with all root fungi fungicidal treatment is of little value while rotation of crops is hardly practicable as the cow pea is grown as a catch crop more or less continuously on the same land.

The success obtained in raising varieties of cotton resistant to its closely allied wilt disease suggested the possibility of controlling the cow pea wilt in the same manner. Mr. Williams of Monetta, S. C., wrote saying that a variety which he had in cultivation and known as the Iron cow pea was resistant to the wilt disease.

Experiments were accordingly carried out by the U. S. Department of Agriculture at Monetta in co-operation with Mr. Williams. One and a half acres were planted, May 29, 1901, in a number of varieties of cow pea, soy bean, velvet bean, and some Japanese forage plants. The varieties were all planted in exactly the same manner and nearly all the plants grew well until July. The conditions after this were rendered more severe by the presence of a root-knot worm or nematode in the soil, and by a severe drought in July and the

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1. The *Agricultural Ledger*, 1893, No. 4.

2. 'Some diseases of the Cow Pea.' *Bulletin 17. U.S. Department of Agriculture, Bureau of Plant Industry*, 1902.

early part of August. The results of the varieties of cow pea are given in brief as follows:

'The Japanese cow peas tested proved to be very early varieties, maturing in two months from planting, when the American sorts were just beginning to blossom. They were small, but quite prolific, and were not greatly injured by the wilt. This was doubtless because of their extreme earliness, as they matured before the disease developed. These varieties would be valuable for trial in the North and for late planting in the South, but for general use they appear to be inferior to the common kinds. At the last they were considerably injured by wilt and nematode.

'Of the American cow peas, all made a good start and had an equal chance, but none made any crop except the Iron.'

The origin of the Iron variety of cow pea is unknown. Although it has proved itself so valuable as a disease-resisting variety, the Iron is stated to be inferior in the quantity of forage and seed produced to some of the other varieties. Experiments in plant breeding are therefore being carried out by the U.S. Department of Agriculture to remedy these defects; and it is suggested that, by selection from resistant individuals of other varieties, it may be possible to obtain a race as hardy as the Iron without its demerits.

In the Gulf States and South Carolina the cow pea[1] also suffers considerably from the attacks of a nematode worm *(Heterodera radicicola)* which produces swellings or galls on the roots. Numerous remedial and preventive methods of dealing with this disease were tried, but none proved satisfactory, being either impracticable or ineffective.

In the experiments mentioned above with the wilt disease it was noticed that the Iron cow pea was not only resistant to the wilt but also to the root-knot worm which badly attacked the other varieties growing side by side with it. Twelve other varieties were grown in the same field as the Iron. In all of them as a combined result of wilt and root-knot it was difficult to find a single plant showing what could be considered normal roots and bacterial tubercles. At the same time 'the roots of the Iron were uniformly fine and slender, showing no indication of root galls produced by the nematodes, but abundant nitrogen tubercles.' Here again it is suggested that an attempt should be made to breed other disease-resistant varieties by selection from resistant plants.

SUGAR-CANE.

The importance of disease-resisting varieties of the sugar-cane is well recognized in the West Indies. In Barbados and Antigua the Bourbon cane, which at one time was the only one planted, was practically forced out of cultivation by its liability to disease, so that the planters were compelled to take up the cultivation of disease-resistant varieties which in other respects

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[1] v. *supra.* 'Some Diseases of the Cow pea.'

were inferior to the Bourbon. At first varieties of cane were introduced from other localities and tried side by side with the Bourbon. The result of one of these experiments with the Caledonian Queen is thus described by Mr. J. R. Bovell:[1] 'To such an extent did this cane resist the disease, that while in some fields the Bourbon canes were so badly attacked that they had to be destroyed, the Caledonian Queens were reported to have yielded two hogsheads of sugar to the acre.'

Subsequently, selection from seedling plants has been largely carried on with the result that numerous disease-resisting varieties have been obtained, some of which are proving themselves of great value also as regards sugar-production.

At present no hybrid canes have, directly, been raised in the West Indies, but in Java, Dr. Kobus[2] has produced many hybrids. The first hybrid raised was a cross between the Cheribon and Chunnee varieties. The Cheribon is a valuable cane but is unfortunately liable to disease; the Chunnee is an Indian cane, inferior as regards sugar production but vigorous and resistant to disease. As a result of numerous experiments Dr. Kobus has obtained hybrids which combine the high sugar production of one parent with the disease-resisting properties of the other. An account of some observations of the writer on the possibility of raising hybrid canes from West Indian varieties is given elsewhere in this volume.

VIOLET.

In the United States it is calculated that a million dollars worth of violets are sold every year; the violets suffer greatly from the attack of a leaf-spot fungus[3] (*Altenaria violæ*), which is calculated to do damage to the extent of $200,000 every year in the United States.

On investigation it was found that certain varieties were more liable to the disease than others. Thus the variety 'Marie Louise' is noted as being far more susceptible than the 'Lady Hume Campbell,' but unfortunately the latter variety, although hardier and more prolific than the 'Marie Louise,' does not produce such perfect flowers.

The above sketch of the work being done is necessarily incomplete, but enough has been put forward to show that, throughout the world, whenever the plant-breeder has been able to devote himself continuously to a thorough study of the question, he has succeeded in raising new varieties which if not immune to diseases, are so far resistant to them, as to give the cultivator the upper hand in his fight with these his worst enemies.

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1. *West Indian Bulletin*, Vol. I, p. 36.

2. Kobus. 'De zaadplanten der kruising van Cheribonriet met de Englesch-Indische variëteit Chunnee.' *Proc. of the East Java Station.* Ser. III. Nos. 1, 12, 21, 33.

3. 'Spot disease of the Violet' by P. H. Dorrett. *Bull. 23. U.S. Dept. of Agriculture. Div. of Veg. Physiology and Pathology*—1900.

SUGAR-CANE EXPERIMENTS AT BRITISH GUIANA.

A Report on the Agricultural work in the Botanic Gardens and the Government Laboratory, British Guiana, for the years 1896-1902 has recently been published. This document forms Part I of a comprehensive report on the experimental Agricultural work carried out in British Guiana under Professor J. B. Harrison, C.M.G., M.A., F.I.C., F.C.S., F.G.S., Government Chemist, and the late Mr. Jenman, F.L.S., Government Botanist, during the period from 1896 to 1902. It is divided into chapters dealing with Meteorology, Old Varieties of Canes, Canes raised from Seed, and Manurial Experiments.

METEOROLOGY.

From a comparison of the rainfall with the exports during the period under review, it is concluded that the crops of the colony are mainly dependent on the amount of rain which falls between December 1, in one year, and October 1, in the succeeding, the best results with regard to sugar products having been as a rule obtained with rainfalls of 65 to 70 inches during these months. The total annual rainfall varied from 50 to 118 inches, and the rainfall between December 1, and October 1, varied from 56 to 99 inches in different years. On the whole the weather conditions during the period 1896 to 1901 were most unfavourable for agricultural research work in the field.

EXTENSION OF WORK.

In consequence of the extension of the work following the grant from the Imperial Department of Agriculture for the West Indies, it was found necessary to transfer the cultivation to a field of the Botanical Department and an area of about fourteen acres of land has been cleared and drained and put in cultivable order.

OLD VARIETIES OF CANES.

The results obtained with twenty of the older varieties of sugar-cane are here given and cover the series of experiments with these canes carried on continuously from 1886 to 1901. The author states that they show conclusively 'that prior to the commencement of the work with varieties raised from seed, no varieties were obtained which, under the test of a long series of successive crops, have given more favourable results than the standard West Indian varieties—the Bourbon and the White Transparent.'

CANES RAISED FROM SEED.

19,118 seedlings were planted out during the period of six years (1896-1901) and tables are given showing the results obtained with the seedlings of different years. The most interesting and immediately important results, however, are

those obtained from seedlings raised prior to 1896 and which therefore have been subjected to a test of some considerable time.

We are told that of the earliest raised Demerara seedlings only Nos. 74, 78, 95, and 102 are retained in cultivation at the Gardens while practically only the first three are in cultivation on the sugar estates of the colony. Nine seedling varieties raised in 1890 are still in cultivation at the Gardens, six of which are being cultivated on the estates, the areas devoted to them varying from 1,727 acres of D. 109 to 8 acres of D. 130; 442 acres of D. 145 are in cultivation.

Several of the seedlings raised in 1892 are stated to be of high promise, but only D. 625 has been grown on any scale on the sugar estates, 79 acres being now occupied by it.

The average results obtained during five crops from the varieties which were retained in cultivation until 1901, as indicated by the tons of saccharose per acre yielded in the expressed juice compared with that yielded by the White Transparent under the same conditions taken as 100, shows that seventeen seedling varieties have surpassed the White Transparent, D. 145 giving 153·6, and D. 109, 137·1 per cent. of the White Transparent yield. These results are chiefly due to an increased yield of cane, and there is much difference in richness and purity of juice in the different varieties. D. 109 and D. 145 have maintained in 1897 to 1901 the estimate formed of their relative value during the period 1892-95, but D. 135, which during the earlier period gave results slightly below those obtained with White Transparent during this later period, comes to the front with a yield of 169 per cent. of the White Transparent variety with relatively rich and pure juice.

In 1896 relatively large plots of certain of the more favourable varieties were established and the results of 1897 to 1901 indicated that Demerara seedlings Nos. 625, 78, 145, 109 and 115 have given larger comparative yields than D. 74, that variety being selected as the standard for comparison 'previous experiments having shown that the sugar yield of No. 74 in the Botanic Garden fields is practically the same as those of the Bourbon or the White Transparent.' 'The two varieties which on the larger plot experiments have given the most favourable return, Nos. 625 and 78, owe their position to the heavy crops of canes yielded by them . . . . the saccharose contents of their juices have been low. . . . . Neither of these varieties appears to mature under the conditions prevalent in British Guiana.' D. 109 grown at the Gardens does not appear to have produced the enormous yields of canes per acre which it has produced on the estates.

The large plot results of seedling canes in Brick Dam field, plants 1900 and ratoons 1901, show that the yield of D. 74 was excelled by D. 625, B. 147, D. 145, D. 109 and D. 1087 in the order given.

Professor Harrison concludes this section of his report with the following: 'From the results of all our experiments

it is clear that several new varieties of canes give yields far in excess of those of the Bourbon on soils on which the Bourbon has ceased or is ceasing to return profitable yields; this result has been very fully corroborated by the experiments conducted on many of the sugar estates of the colony. It marks an advance of high importance, but the still more important, the crucial question:—Will any of the new varieties give yields in excess of those of the Bourbon on soils where that cane flourishes, and if excess yields are obtained will they be profitable from the manufacturing point of view,—still remains unanswered.

GENERAL DEDUCTIONS WITH REGARD TO SEEDLING CANES.

Details are then given of the results from seedlings raised during the period 1894 to 1899, and the following general deductions recorded as the result of the work of these and earlier years:—

(1) It is not possible to form an opinion as to the probable richness of the seedling progeny from the richness of the parent cane. This is applicable not only to the actual seedling but to canes propagated from it by cuttings.

(2) In the majority of cases the saccharine richness of the parent variety appears not to be transmitted to either the actual seedlings or to canes propagated from them by cuttings. But in the cases of a few varieties there has been found a tendency for the seedlings to approximate to the sugar contents of the parent kind.

(3) Similar conclusions hold good with regard to the percentage from non-sugars ('gums') present in the juice. The glucose-contents, and therefore the glucose-ratio and, in part, the quotient of purity are governed by the relative degree of maturity of the canes examined and analysed.

(4) Except in some of the more inferior kinds, among both the old varieties and seedling varieties, the size of the individual cane from which the seed is taken apparently in no way affects the size of its offspring, but there is no doubt, as has been repeatedly shown during the experiments, that the average size of the parent variety, with occasionally conspicuous exceptions, closely governs the average size of its offspring.

(5) Experience has not altogether confirmed the earlier experience with canes obtained from the seeds of seedling canes. Although the majority of the seedlings obtained from the seed of the seedling varieties show deterioration, some have been obtained of considerable promise.

(6) The fertility of seeds obtained from seedlings is far greater than it is in those obtained from the majority of kinds of the older canes.

(7) While the seedlings of the older varieties with but few exceptions show marked tendency to variation, the seeds obtained from seedling varieties do not possess this property to anything like the same extent, and in many of them the

offspring appears to come fairly true to parentage; this is especially the case among those we have studied with No. 95 and No. 74.

(8) The range of variation among the seedlings is far greater in those obtained from parents which are striped than amongst those derived from self-coloured canes, and this is so with regard to colour, size, and sugar-contents.

Chapter III concludes with a list of canes recommended as 'worthy of the attention of the planters of the colony for careful Experimental Cultivation' which includes Demerara seedlings 74, 109, 135, 145, 625 and also Barbados seedling 147: and a table is given showing the area of the different seedling varieties under estate cultivation to amount to something like 4,000 acres.

MANURIAL EXPERIMENTS.

A large proportion of the report is taken up by the results of the manurial experiments, and 'the following are the general deductions as to the action of manures and of lime upon the crops of sugar-canes grown upon very heavy clay-lands and under the climatic and meteorological conditions existing at the Botanic Gardens from June 1891 to May 1902:—

(1) 'Nitrogen in the forms of sulphate of ammonia, nitrate of soda, raw guano, and dried blood exerted a favourable influence upon the yield of the sugar-canes and is without doubt the manurial constituent the supply of which mainly governs the yield of the plant.

(2) When supplied in quantities capable of supplying not more than 40℔. of nitrogen per acre there was practically no difference in the effects of sulphate of ammonia and of nitrate of soda, but on the whole the former is, in my opinion, the preferable salt to apply. Dried blood and raw guano were inferior to each of these. In the earlier crops of the experiments the best results were obtained by a mixture of one-third nitrate of soda and two-thirds sulphate of ammonia, but during the latter years this mixture has not proved more efficacious than either sulphate of ammonia or nitrate of soda alone.

(3) Where applied in quantities supplying more than 40 ℔. of nitrogen per acre, sulphate of ammonia is the best source of nitrogen for the sugar-cane on the alluvial soils of British Guiana.

(4) The sugar-cane made more effectual use of the nitrogen supplied by 200 ℔. per acre of sulphate of ammonia and by 250 ℔. of nitrate of soda than it did of that supplied in heavier dressings. On the whole, dressings of from 2 to 3 cwt. of sulphate of ammonia per acre appear to be the most certainly profitable applications of nitrogen, although at favourable season the use of still higher proportions may prove successful.

(5) The application of superphosphate of lime to plant-canes gave increased yields when added to manurings of nitrogen and potash. But little, if any, advantage was gained by the use of phosphates with ratoon-crops, and I am of

opinion that manurings with superphosphate of lime or with other manures containing phosphates should be restricted to plant-canes, the ratoons being manured with nitrogen only.

(6) Mineral phosphates to give increased yields must be applied to the soil in such heavy dressings as to render their use decidedly unprofitable.

(7) As far as the experiments indicate, Thomas phosphate powder (slag-phosphate) is the preferable source of phosphates for application to plant-canes in lieu of super-phosphate of lime.

(8) The addition of potash when applied either as sulphate of potash or as nitrate has exerted little or no effect. The normal weathering of the constituents of the soil sets free for each crop potash in excess of the quantity necessary for the requirements of the plants. This holds good under the conditions existent here, when the greater proportion of the potash taken up by the plants is directly returned to the soil, but where practically the whole of the produce is removed from the land, it is probable that partial potash-exhaustion may take place in the course of a few crops.

(9) The use of lime has resulted in largely increased yields. But whether or not its use will result in profitable increases depends on the price of sugar. Its action appears to have been principally mechanical in improving the texture of the land, and it is a question of much importance whether this effect could not be obtained at a lower cost and hence more profitably by the use of light ploughs or other cultivators.

(10) The results confirm those of previous experiments that neither the addition of phosphoric acid, of potash, or of lime to the manures favourably affects the sugar-contents of the juice of the canes. The effects of nitrogenous manurings appear to be to somewhat retard the maturation of the canes and thus the juice of canes matured with them is as a rule not so rich in saccharose as is that of canes grown without manure. But this effect is far more than offset by the larger yields of produce resulting from the application of nitrogenous manures, and to the fact that the increases produced by the nitrogen are principally due to the development of the stalks in length and in bulk and not to abnormal increases in the amounts of tops and leaves or the production of new shoots to the stool. In this the effects of nitrogenous manures on the sugar-cane are very similar to those on others of the *Gramineae.*'

This report contains a very large amount of condensed detail of great interest and forms a valuable contribution to the literature of Sugar-cane Experiments already so largely enriched by its distinguished author, Professor J. B. Harrison.

HYBRIDIZATION OF THE SUGAR-CANE.

BY L. LEWTON-BRAIN, B.A. (Cantab.)

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Before dealing with the subject of the hybridization of the sugar-cane, it will perhaps be advisable first of all to describe briefly the structure of a 'typical' or perfect flower, and then to indicate the main points in which the sugar-cane flower differs from this.

As an example of a typical flower I will take that of the lily, because the lily belongs to the same great class of flowering plants, Monocotyledons, as does the sugar-cane, and so a comparison between the flowers is more easily made. Starting from the outside of the lily flower we find first six coloured (*i.e.* not green) leaves, forming together the *perianth*: these leaves are arranged in two rings, three in each ring. In many flowers only the inner of these two rings is coloured; it is then known as the *corolla* and its leaves are the *petals*, the outer ring in such cases is green and inconspicuous: it is known as the *calyx* and its leaves as *sepals*. The function of the coloured parts of the flower is to attract insect visitors, while that of the green calyx is mainly to protect the more delicate inner parts of the flower, while this is in bud. Inside the coloured perianth we find six *stamens*, again arranged in two rings, the stamens of the outer ring alternating with those of the inner. Each stamen consists of two parts, a slender stalk or *filament* and a kind of yellow box on top of the filament, the *anther*. Inside the anther is a large quantity of yellow dust, the *pollen*, composed of an innumerable number of *pollen grains*; it is inside the pollen grains that the male reproductive cells of the plant are formed. Finally, quite in the centre of the lily flower, we have the *pistil*; this is composed of three parts: at the base is the large swollen *ovary*, at the top a flattened, sticky, three-lobed *stigma*, and joining the top of the ovary to the stigma is the *style*. If we cut across the ovary we find it is composed of three chambers, in each of which are a large number of small white bodies, the *ovules*. The ovule has a complicated structure, which it is not necessary to enter into, it is sufficient for my present purpose to point out that inside the ovule there is formed a small body in which the female reproductive cell, the ovum, is developed. The stigma is the receptive place for the pollen and it is sticky in order that the pollen grains may remain adhering to it. When the pollen grain is brought to the stigma (in the case of the lily this is usually done by insects) it germinates and puts out a small tube, this tube grows through the tissues of the style, taking food from these as it goes, down through the ovary and then towards an ovule: on reaching the ovule it grows to a spot near the ovum and then the tip of the tube dissolves away, the male cell which has travelled down the tube now passes out and moves towards the ovum with which it fuses. This fusion of the male and female cells is the process of fertilization. What is often called

fertilization, namely the transference of the pollen from the anther to the stigma, is more properly called pollination.

It is evident from what has been said above that the only essential parts of a flower, when this is considered as an organ of reproduction, are the stamens and the pistil. The other parts—corolla and calyx—are merely accessories, the corolla to attract insects which bring about pollination, and the calyx to protect the other parts when in the bud.

The 'arrow' of the sugar-cane is a part of the stem which bears the flowers, that is, what is technically called an *inflorescence.* The inflorescence, in this case, is repeatedly branched and the ultimate branches bear laterally a number of what are called *spikelets.* In the sugar-cane each spikelet only contains one flower, but in many other plants of the order to which the sugar-cane belongs—the true grasses or *Gramineae*—each spikelet contains several flowers.

On examining one of these spikelets under a dissecting microscope, one finds on the outside three chaff-like scale leaves, the two outer are stiff and green, while the innermost, which is packed inside the first one, is thin, white and membranous. From the base of the spikelet spring a large number of stiffish hairs, it is these that give the arrow its glistening, silky appearance in the sun. The three scale leaves are not really a part of the flower, though at first they might be mistaken for a calyx, the two outer ones are known as *glumes*, the inner as a *palea.* In most grasses there are two glumes at the base of the whole spikelet and then two paleæ at the base of each flower.

Dissecting away the glumes and palea we come to the flower proper ; this consists only of stamens and pistil, there is no perianth. At the base of the flower very careful examination reveals the presence of two minute scales, the *lodicules* ; these are sometimes thought to represent the remains of a perianth, but Hackel* in his work on grasses, gives reasons which negative this view, so that the grass flower may be considered as naked, *i.e.*, without calyx or corolla. The protective functions of the calyx are performed by the glumes and paleæ, while, as the grasses are all wind-pollinated, no coloured corolla for the attraction of insects is necessary.

In the lily we found there were six stamens, in the grass we see there are only three, the outer ring of stamens in the lily not appearing in the sugar-cane. It is noticeable, also, that the anthers are much more loosely attached to the filament in the sugar-cane than in the lily. This is brought about by the fine end of the filament being attached to the middle and not to the base of the anther ; the anther is, in fact, *versatile.* This loose attachment of the anthers is of service in that, when the anthers open, the pollen is much more easily scattered by the wind than would be the case if the anthers were firmly fixed on to the filaments.

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* Hackel. *The True Grasses.*

The pistil of the sugar-cane differs considerably from that of the lily. The ovary, instead of possessing three chambers each with numerous ovules, shows but a single chamber and that contains only one ovule. Springing from the top of the ovary we have two red, very much branched stigmatic plumes, in place of the flat, sticky, tri-lobed stigma of the lily. This feathery form of stigma is that best adapted to catching pollen which is being blown about by the wind.

The function of the lodicules is an interesting one. When the flower is ripe, they take in water and swell up, so forcing the bases of the glumes and palea apart, and letting the stamens and stigmatic plumes be exposed to the air.

SELECTION AND HYBRIDIZATION.

The raising of new improved varieties of cultivated plants is one of the most important parts of the work of the scientific agriculturist. The improvement may take place along two lines,—the first is an increased yield of the product for which the plant is cultivated, the second is increased resistance of a plant to disease; and both these objects should be kept in view by the plant-breeder. For instance, in the report of the Secretary given in the *Yearbook* of the United States Department of Agriculture for 1900 it is stated, with regard to corn breeding, that 'The features of importance aimed at in connexion with this work are early maturity, drought-resistance, resistance to smut, increased protein and increased yield.' A variety which produces a very good yield but of which the greater portion of the crop is destroyed every year by disease is of little use to the practical agriculturist, nor is one, which, while resistant to disease, gives a very poor yield.

There are two chief ways in which new and improved varieties are raised:—

(1) By a process of selection.
(2) By hybridization.

The process of selection has, no doubt, been carried on from the very beginning of agriculture. In sowing seed for his next year's crop the primitive agriculturist would naturally select that from what were, to his mind, the best plants, and this process carried on year after year would necessarily result in the improvement of the variety.

In raising new varieties by this method one takes advantage of the well-known fact, that plants raised from seed are never exactly like the parent. The plant-breeder then, sows seed, and from the crop thus obtained he selects those plants which, according to his point of view, are better than the parent form and are worth perpetuating, and discards all others. He then has to fix his new variety; in the case of plants which, like the sugar-cane, can be reproduced from cuttings, this is easy, as plants raised from cuttings always come true to the parent; but with plants which are only reproduced from seed the process is a long and tedious one, necessitating the careful selection of seed year after year, until nearly all the plants come true.

In this connexion the following extracts from the *Year-book* of the United States Department of Agriculture for 1899 on the improvement of cotton is interesting as showing what can be done by careful selection : –

'About 1785 seeds of this (Sea Island) cotton were brought to Georgia from the Bahamas. Notwithstanding the good care they received and the mild winter, the plants were killed down, but they came up again from the roots, and with this start succeeded in ripening a few seeds before the first frosts in the fall. The earliest of these seeds were sown in turn and by continuing this process of selection the flowering period became earlier and earlier, until now the plants ripen a large proportion of their seeds before frosts, even along the coasts of the Carolinas. Besides striving to obtain earlier maturing sorts, very careful selection has for years been made with a view to increasing the length, fineness and strength of the staple. This selection is regularly practised by all intelligent growers and to-day it may be regarded as one of the necessary cultural methods. Every year a special patch of cotton is grown from selected seed : the plants in this patch are examined very carefully and the seed of the best individuals retained for planting a similar patch the next year, the seed of the remaining plants being used to plant the general crop. Under such continuous and vigorous selection the length and fineness of the fibre have gradually increased until it is now recognized as superior to that grown anywhere else in the world and commands the highest price in the market.'

The amount of improvement that can be obtained by careful, continuous and rigid selection of the best plants to use as parents is well shown in the case of the sugar-beet.* In France and Germany where sugar-beets have been continuously cultivated and selected for many years, the yield of recoverable sugar per acre has been raised from 6 per cent. in 1799 to 12·15 per cent., and while in 1836 eighteen tons of beet root were necessary to produce one ton of sugar, in 1889 this quantity was reduced to 9·25 tons.

In England, and to a greater extent in the United States, continual selection of the chief crops is being carried on by private plant-breeders and by experiment stations, and a constant improvement is maintained. For instance, at the Minnesota experiment station, varieties of flax were cultivated and selected for six years ; during that time varieties 32 inches tall were raised from varieties only 26 inches tall, the length of the fibre being increased by more than 20 per cent. Similar results are being obtained with wheat, barley, oats, Indian corn, and, in fact, with all cultivated crops, wherever agriculture is carried on in a scientific manner.

Since the independent discovery in 1885 by M. Soltwedel†

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* See *Farmer's Bulletin No. 93*, U.S. Department of Agriculture.

† Mededeelingen van het Proefstation Midden-Java te Semerang over Suikerriet uitgegeven door Dr. Franz Benecke, met 23 figuren. Semerang, G.C.T. van Dorp & Co. 1889.

in Java and by Professor Harrison and Mr. Bovell in Barbados.* that the sugar-cane does produce fertile seed, a process of selection has been continually carried out with it both in Java and throughout the West Indies (including British Guiana). With the sugar-cane, as I have already mentioned, the process is rendered much easier because as soon as a good variety is obtained, it can be fixed at once by growing plants from cuttings.

The method of selection adopted in Java is described by Dr. Kobus in the *Revue des Cultures Coloniales*, T. viii. 1901. The following translation is taken from the *Trinidad Bulletin*, Vol. iv, No. 29 :—

'All small and weak plants (*i.e.*, seedlings) and those whose quality do not recommend them for cultivation are cut down before the crop. This selection we rigidly carry out and up to 80 per cent. of the canes are rejected. The rest are analysed individually : a second selection is made and the canes which are richest in sugar are alone propagated by cuttings. Of 2,000 plants sown in 1899 only 100 were left in 1900 after this double selection. The following year the plants grown from the cuttings also undergo the process of double selection, first according to their outward appearance, and then by chemical analysis ; this is repeated a third year.'

In Barbados, British Guiana and other parts of the West Indies, similar careful selection is carried out. Thousands of seedlings are raised every year : of these a few of the best are selected, and after careful trial on experiment plots for several years under experimental conditions in comparison with other standard canes, the best are again selected and are recommended to the planters for their final trial under estate conditions, and the planter finally selects those which he thinks suitable for cultivation.

The objects that should be kept in view in the raising of new varieties of cane were well stated by Professor d'Albuquerque at the Agricultural Conference of 1901 (*West Indian Bulletin*, Vol. ii pp. 23-4.) :—

(1) A large tonnage of canes per acre.
(2) A good milling cane, *i.e.*, a cane that passes through the mill without breaking off and gives a high percentage of juice.
(3) A juice rich in sugar.
(4) A high degree of purity in the juice.
(5) A cane resistant to disease.
(6) An early maturing cane.
(7) A drought-resistant cane.
(8) A cane of which the plant canes germinate readily.

That the seedlings of the sugar-cane vary enormously is a well-known fact. For instance, in the British Guiana *Report on the Agricultural Work in the Botanic Gardens and the Government Laboratory* for 1896-1901, Professor Harrison states

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* Harrison. *Kew Bulletin*, 1888 p. 294.
Morris. *Journal Linnean Society* xxviii, 1891.

that 'in the majority of cases the saccharine richness of the parent variety appears not to be transmitted to either the actual seedlings or to canes propagated from them by cuttings and that 'similar conclusions hold good with regard to the percentage of non-sugars present in the juice.'

The difficulty that the breeder of sugar-canes has to contend with is that the vast majority of these seedlings are less valuable than the parent forms.

The results of the work done in the selection of new varieties of the sugar-cane are well known to West Indian agriculturists. Several new varieties have been introduced, some of which are proving themselves of great value in regards sugar-production, etc., while they are far superior to the Bourbon with regard to their resistance to disease. D. No. 74 has even gone farther afield and, in Louisiana, has on trial proved itself a better cane than the Louisiana Purple and Striped (see *Agricultural News*, Vol. II, p. 51).

Hybridization as a result of cross-fertilization is another process that is extensively used in scientific agriculture in the production of new varieties. New varieties of wheat and other cereals, beet, and indeed most other cultivated plants, have been raised by this method, but it has been used far more with plants, which, like the sugar-cane, can be propagated by vegetative methods, by cuttings, buds, grafts, etc. The reason is, that the seed obtained from hybrids is far more variable than that from pure-bred plants, and until recently nothing was known of any laws governing this variation, and the tendency to revert to the parent forms.

As an example of what is done in this way, mention may be made of the new varieties of wheat and other cereals which are raised by cross-breeding by Messrs. Garton in England. In their experiments crossing is not confined to two varieties, but the hybrid resultant on the first cross is pollinated with pollen from another hybrid, and the progeny is again crossed with another double hybrid and so on. In this way a large amount of variation is obtained, and among the multitude of abortive, inferior forms, a few good specimens appear, which are grown for a number of years until fixity of type has been secured. By crossing cultivated wheat with an inferior 'spelt' wheat from Southern Asia, a hybrid was obtained which was superior to the cultivated parent in the amount of yield, in the standing power of the crop, and in not shedding its seed before harvest. By crossing oats with the common wild oats of Great Britain hybrids of greater hardiness, standing power and fertility have been obtained after numerous experiments.

In most cases in order to obtain these hybrids, artificial cross-pollination has been resorted to, and in plants with few flowers widely separated on the plant, the process is a fairly simple one. The anthers are removed from the flower which is to bear seed before it opens and the flower is then immediately tied up in a bag to prevent pollen being brought to the stigma by wind or insects. Great care must be taken during the process of emasculation not to injure the style or stigma of the pistil. As soon as the stigma is ripe the bag is removed

the desired pollen is applied to the stigma with a camel-hair brush or small scalpel, and the bag is again tied over the flower, where it remains until the seeds are beginning to be formed. The flower from which the pollen is taken has also to be covered with a bag in order to prevent its pollen being contaminated by other brought by wind or insects.

Crossing is resorted to for two reasons. The first is that the offspring of a cross, as already mentioned, is extremely variable, so that crossing may be regarded as a means of inducing variations for selection to work on. This is an important point with many cultivated plants which have been raised from seed for many generations, the seedlings of which therefore generally closely resemble the parent form. With the sugar-cane this would not be of any great importance, as the seedlings generally differ widely from the parent plant. Even here, however, it is being found that 'while the seedlings of the older varieties with but few exceptions show marked tendency to variation, the seeds obtained from seedling canes do not possess this property to anything like the same extent, and in many of them the offspring appears to come fairly true to parentage.' (British Guiana, *Report on the Agricultural Work in the Botanic Gardens and the Government Laboratory*, 1896-1901.)

Crossing is also resorted to in the hope that some of the offspring will combine the good characters of the two parents. Thus if we had two varieties of sugar-cane, one of which produced excellent canes but was delicate and very susceptible to disease, while the other variety gave inferior canes but was very hardy, we might hope by crossing, after numerous trials, to get a hybrid form which combined the excellent production of one parent with the hardiness of the other; or, by crossing a variety which gives a large crop of inferior quality with one that gives a small crop of good quality, to get a hybrid form which will give a large crop which is at the same time of good quality; but these results must not be looked for at the first trial.

In the West Indies, up to the present, there have been two methods by which hybridization might have been effected. The first, which may be called the natural method, is simply to plant alternate rows of two varieties of cane which are known to arrow at the same time, and trust to chance that cross-pollination will take place. It is evident that under these conditions a good deal of uncertainty must exist as to the parentage of the resultant seedlings. A large proportion of them will almost certainly not be hybrids but will be the result of pollination with pollen from the same or other arrows of the variety that produces the ovules. There is very little doubt that some of the seedling canes that have already been raised in the West Indies are the result of accidental crosses, brought about by planting several varieties of canes close together. Thus Mr. Hart* has noticed that 'our greatest variation in sugar-cane seedlings was secured when the seed was

* *Trinidad Bulletin*, Vol. iv., No. 24.

taken from a plot containing as many as thirty or forty varieties of canes planted close together and flowering at the same period.' It is evident that under these conditions a certain amount of crossing must take place, but the difficulty is that it is impossible to tell how much crossing has taken place or which seeds are the result of such crosses.

Again Professor Harrison* has stated that he 'considered that much of the success (in raising seedlings of the sugar-cane) was due to natural cross-fertilization.'

An artificial method of securing cross-pollination recommended by Professor d'Albuquerque † was to 'bag each arrow under experiment some time before it is ripe: and when the arrows in the bags are ripe, to shake the contents of the bags of one variety into the bags covering the arrows of another, the latter bags being temporarily opened at the top to receive the pollen, and then closed up, every possible precaution being taken to prevent during the transference the access of pollen from any other source.'

As Professor d'Albuquerque himself points out, this method does not secure us from self-pollination, as the stigma may receive pollen from the anthers of the spikelets of the same arrow, probably there would be more self-fertilization than crossing and it would be difficult to tell which seedlings were the results of which.

Again we might resort to artificial cross-pollination pure and simple as described above. In that case we should have to take all the spikelets of an arrow and either emasculate or remove them, before any of the spikelets were beginning to open, and this would have to be done without injuring the very delicate ovary and stigmatic plumes and while perched on a platform; to anyone who has dissected an immature spikelet of the sugar-cane, the difficulties of this process will be at once apparent. The subsequent pollination with pollen from another variety of cane would be comparatively easy.

There is, however, a method of securing natural hybridization which has been tried in Java‡ and has been found to give good results. It had been noticed there that one of the best canes, the 'Cheribon,' did not produce seed, and Dr. Wakker in 1894 showed that this was due to the fact that the Cheribon (as also some other varieties) did not produce fertile pollen while its pistil was normal. Following up this fact Dr. Kobus planted the Cheribon in rows alternating with rows of another variety of cane which was known to possess fertile pollen: the result was that the Cheribon produced fertile seeds, which obviously must

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* See *International Sugar Journal*, Vol. iii, p. 134.

† d'Albuquerque. Notes on Artificial Cross-Fertilization of the Sugar Cane, *West Indian Bulletin*, Vol. i.

‡ Went. *International Sugar Journal*, Vol. iii. The Cultivation of the Sugar-cane.

Kobus. *Revue des Cultures Coloniales*, T. viii, 1901.

Wakker. *Botanisches Centralblatt*, xvii. 1896. Die generative Vermehrung des Zuckerrohrs.

have been the result of inter-crossing. Since then Dr. Kobus states that together with M.M. Bouricius and Mognette he has produced thousands of hybrid canes: in 1900 he planted more than 8,000 of them.

In October 1902, Dr. Morris suggested that I should examine the arrows of as many different varieties of sugar-cane as possible, to find out whether the flowers are usually hermaphrodite (with both stamens and pistil), or staminate (without pistil), or pistillate (without stamens). Mr. J. R. Bovell kindly supplied me with arrows from fifty-one varieties of cane, which were examined when fresh.

In each case fifty spikelets were taken at random from the arrow and examined under the dissecting microscope. The spikelets were dissected out to determine whether the enclosed flowers possessed both stamens and pistil, or only one or neither of these. I may state at once, that every flower examined possessed both stamens and pistil, and that so far as examination under the dissecting microscope showed they were always normal.

Bearing in mind the results of Drs. Wakker and Kobus in Java, I took another twenty spikelets from each arrow, removed the anthers from the stamens and dissected out the pollen which was then examined under the microscope. In nearly every case I found that the anther contained two kinds of pollen grains. One kind was large, well-shaped and full of dark granules of reserve food materials; this I took to be the fertile pollen of Dr. Wakker. The other kind was smaller, more or less irregular in form, and without granular food reserve; this I regarded as infertile pollen.

I also found that the proportions of the fertile to infertile pollen differed in the anthers of different varieties. By examining twenty spikelets from two or three different arrows, whenever this was possible, I found too that the proportion was a fairly constant one for each variety.

I was therefore able to divide the varieties into three classes according to the proportion of normal pollen in the anthers of their flowers, as follows:—

Class I.

Varieties in which the anthers show a large proportion of normal pollen:—

B. No. 619	B. No. 208
T. No. 24	D. No. 842
B. No. 620	B. No. 2,510
B. No. 1,378	B. No. 2,550
B. No. 1,462	D. No. 1,897
B. No. 1,646	B. No. 3,471
B. No. 1,379	B. No. 1,521
B. No. 1,222	B. No. 1,480
B. No. 1,537	B. No. 1,221

It is noteworthy that all the varieties coming under this class are seedling canes and most of them of recent origin. This probably explains why it is found easier to raise fertile seed from seedling canes than from older varieties. It is simply because these young varieties produce a larger amount of normal pollen.

Class II.

Varieties in which the anthers show a very small proportion of normal pollen :—

White Transparent	Jamaica Cane
B. No. 376	Queensland Creole
B. No. 379	B. No. 2,663
Rappoe	B. No. 3,381
B. No. 390	D. No. 1,438
White Sport Cane	B. No. 1,490
B. No. 147	B. No. 1,594
W. No. 4	B. No. 1,360

Class III.

Varieties in which there is a moderate proportion of normal pollen in each anther :—

D. No. 95	B. No. 1,607
W. No. 2	B. No. 1,475
Naga B.	B. No. 1,234
Caledonian Queen	B. No. 1,719
B. No. 973	B. No. 1,584
Striped Singapore	B. No. 3,475
D. No. 74	B. No. 1,464
B. No. 2,885	B. No. 1,371
B. No. 2,769	

It will be evident, from what has already been said, that in endeavouring to obtain hybrids only canes of varieties included in Class II. should be used as seed-bearing parents. If canes belonging to any other class are used there will always be the risk of pollination by pollen of the same variety of cane; as the canes of this class have very little or no normal pollen, this risk is with these reduced to a minimum, and if any fertile seeds are produced by these canes, they will almost certainly be the result of hybridization. As pollen-producing parents it is obvious that the best are those included in Class I.

It will probably be sufficient if a variety belonging to Class I. and one belonging to Class II. which are known to arrow at about the same time, are planted in alternate rows. Care should, of course, be taken that the plot is sufficiently isolated to prevent there being much risk of pollen from a third variety reaching the stigmas of the seed-bearing canes and so complicating the results and rendering the parentage of the seedlings produced again a matter of uncertainty. With the knowledge thus put forward Professor d'Albuquerque's

suggestion might be acted upon, without there being any risk of self-fertilization. It is hoped that these observations will be continued and extended during the next arrowing season.

BUD VARIATION IN THE SUGAR-CANE.

In the *West Indian Bulletin* (Vol. II, pp. 216-223) a *résumé* was given of previously recorded instances of bud variation in the sugar-cane, and two cases which had more recently been brought to the notice of the Department were described in detail, illustrated by coloured plates.

In one of these new examples a striped or 'ribbon' cane had given rise to lateral branches, some striped and others unstriped. 'The resulting appearance was a striped parent cane bearing, on the one side two striped shoots, and on the other side two unstriped shoots, (*loc. cit.*, p. 210 with plate).

The second example presented the appearance of seven striped canes and six unstriped canes springing from a common stock. Mr. J. R. Bovell, F.L.S., Agricultural Superintendent of sugar-cane experiments at Barbados, reported: 'After careful examination I am satisfied that in this clump of canes there is a decided case of 'sport' or bud variation, as the piece of cane originally planted was a bit of ribbon. From a bud of this ribbon was produced a white cane which in turn produced, from a bud below the surface of the ground, a ribbon cane'. (*loc. cit.* p. 220 with plate).

These sport canes were exhibited at the Barbados Agricultural Society by Dr. Morris, C.M.G., who laid stress on the possible economic value of these cases of bud variation.

Evidence of the superiority sport canes sometimes show over the parent stock was also brought forward from the results of earlier observers. Mr. Horne, formerly Director of the Botanical Gardens, Mauritius, in a letter to the Director of the Royal Gardens, Kew, dated 1890, said 'Many of these (sports) are hardier than their parents, and yield more sugar.' (*loc. cit.* p. 222.) Mr. J. Clarke of North Queensland was quoted to the effect that 'I have also noticed that the yellow sports have a tendency to grow sweeter than the coloured canes of the same family.' (*loc. cit.* p. 222.)

In order to put the relative merits of the sport canes and the original stock to a strictly comparative test, they were planted at the Experiment Station, Dodds, Barbados, side by side, in the same field, with other experiment canes.

The following figures taken from the Report of Messrs. d'Albuquerque and Bovell on the Agricultural work carried on at Barbados, 1900-02, under the direction of the Imperial Department of Agriculture for the West Indies, show the

results obtained. For comparison the return of White Transparent grown in the same field is also given :—

Cane.	Canes. Tons per acre.	Juice per acre in Imperial gallons.	Saccharose per gallon.	Quotient of purity.	Saccharose per acre.
Original Stock* (ribbon)	21·80	2,696	2·310	93·03	6,228
Sport cane (white)	27·27	3,555	2·270	91·64	8,070
White Transparent	23·93	3,063	2·001	86·59	6,129

The yield from the sport cane in the experiments exceeded the yield from the original stock cane, by nearly 2,000lb. of saccharose per acre. This superiority was due to the higher tonnage of the white canes, their juice being slightly less rich in saccharose, and slightly less pure than the ribbon stock. The juice of both original stock and sport was rich in saccharose, and the results, so far, warrant their continued experimental cultivation.

CASSAVA FROM COLOMBIA.

The question of cassava cultivation has recently occupied considerable attention in the West Indies. The plant has been cultivated in these colonies from time immemorial as a vegetable, and for the manufacture of tapioca and cassaripe. It was at one time believed, and the statement is still often repeated, that of the two usually recognized varieties, 'bitter' cassava and 'sweet' cassava, the former alone contains hydrocyanic acid in its milky juice.

The experiments of Prof. Francis, formerly Government Analyst of Trinidad, recently repeated by his successor Prof. Carmody, demonstrated that some sweet cassava found in the West Indies often contains a comparatively high percentage of hydrocyanic acid. For this reason it is essential that cassava should only be eaten after very thorough cooking. Deaths occur, from time to time, in the West Indies, from neglect of this precaution, and to attempt to remedy this a leaflet has recently been prepared and distributed by the Imperial Department of Agriculture, giving simple, practical directions for the preparation of cassava, and for

* In the Report this is described as 'Sport Ribbon,' a name employed on the label in the field to distinguish this particular plot of ribbon cane.

treating people poisoned by cassava. (Leaflet. No. 7. *Hints and Information in regard to Cassava Poisoning.*)

Mr. Robert Thompson, formerly Superintendent of the Botanic Gardens, Jamaica, introduced, in 1901, to the West Indies new varieties of cassava from the United States of Colombia, where 'poisonous varieties are unknown to the people.' These varieties have been cultivated by Mr. Thompson in Jamaica, and recently analysed by Mr. H. H. Cousins, M.A., F.C.S. The results are of great interest inasmuch as they show that 'these Colombian cassavas are marked by a very high starch content and are practically free from prussic acid.' Should these characters be retained under cultivation in the West Indies a great advance will have been made. Samples of these varieties have been secured by the Imperial Department of Agriculture and are now under cultivation at the Experiment Station, Montserrat.

Mr. Cousins' paper giving the results of his analysis, together with a memorandum by Mr. R. Thompson, are reproduced in full below, from the *Bulletin of the Department of Agriculture, Jamaica*, Vol. I., pp. 35-8 :

Mr. Robert Thomson, formerly Superintendent of Public Gardens in Jamaica, has taken a leading part in urging the claims of cassava as a food-product for districts in the tropics, and also as a profitable source of starch and glucose for commercial purposes. At the instance of the Hon. Sydney Olivier, the Chairman of the Board of Agriculture, I was instructed to arrange with Mr. Thomson for the analysis of a unique collection of varieties of cassava brought by him from Colombia as a guide to their economic value.

This has been done. As the results show, these Colombian varieties are marked by a very high starch content and are practically free from prussic acid. These varieties were grown at Half Way Tree on the Liguanea plain, and it is possible that some varieties, as Mr. Thomson suggests, would succeed better in the hills. It is hoped, so soon as stock of these varieties has been established, to conduct careful experiments as to the agricultural yield and the content of starch. It will also be of interest to note whether acclimatization will cause an increase in the amount of prussic acid obtainable from the tubers.

A comparative test of these cassavas against our creole stock of bitter and sweet varieties is eminently desirable. Should these Colombian varieties maintain their promising character, their introduction from the interior of Colombia by Mr. Thomson to the West Indies and the Indian Empire must be regarded as a signal service.

The seventeen varieties were delivered on the afternoon of November 28, in a perfectly fresh state, and were immediately prepared and sampled for analysis. Determinations of moisture, total solids, starch and hydrocyanic acid were made. The latter was determined by Carmody's* method

* *Annual Report* Government Analyst, Trinidad, 1901.

of soaking slices in water. The hydrocyanic acid was estimated after twenty-four hours soaking and again after forty-eight hours in a fresh quantity of water. The amounts so obtained were remarkably low, far below Carmody's minimum for sweet cassava grown in Trinidad. I anticipate as possible that these Colombian varieties may develop a higher prussic acid content when acclimatized to Jamaica. In their present state these cassavas are practically non-poisonous, and the analytical data fully support the reputation for harmlessness which Mr. Thomson ascribes to them as grown in Colombia.

Carmody's average for bitter cassava grown in Trinidad is 0·022 per cent., and for sweet cassava 0·010 per cent., and of the latter, peeled for use as a food-product, 0·007 per cent. of hydrocyanic acid. The average of these seventeen Colombian varieties is only 0·0017 or only one-sixth of that in Trinidad sweet cassava. Further experiments are in hand to test the distribution of the poisonous hydrocyanic acid as between the inner and the outer portions of the tubers. Carmody (*loc. cit.*) states that his experiments indicate that an analytical difference can be drawn between 'sweet' and 'bitter' cassava by the fact that in the former most of the hydrocyanic acid is derived from the external portion, while in the latter the poison is uniformly distributed.

As regards starch yield, the variety *Governor Hemming* leads with 36·5 per cent., a very high content closely followed by *Cabesa Dura*, *Negrita*, *Helada* and *Paloma*.

The three Pacho varieties (2, 3 and 4) are the lowest in starch content with 22·3 to 19·3 per cent. Mr. Thomson states that these varieties should do well at a high elevation. There is thus a variation of 90 per cent. in the starch content of these seventeen varieties. Given a high percentage of starch and large agricultural productivity, the yield of starch in Jamaica should be considerable.

The variation of moisture from 54 to 72 per cent. is also worthy of note, as also the variation of 3·5 to 19 per cent. in solids other than starch.

It is hoped on a future occasion to supply data in which the composition of the tubers shall be returnable as an agricultural yield per acre of food or of commercial starch and glucose.

Appended are the analyses in which I was assisted by Messrs. Hammond and Wortley.

An interesting Memorandum from Mr. Thomson follows.

In view of the importance of cassava both as a food-product and a source of starch, arrangements have been made for a systematic trial of various native varieties of cassava which are held in repute. Analysis and field results will be published in the *Bulletin of the Department of Agriculture, Jamaica* when they are ready.

Results of Analysis.

(in order of Starch-Content.)

No.	Name.	Ref. No.	Moisture.	Starch.	Solids not Starch.	Hydrocyanic Acid.
1	Governor Hemming (Notoseves) ...	21	57·17	36·50	6·33	0·0018
2	Cabesa Dura ...	16	5·469	35·40	9·99	0·0010
3	Negrita ...	15	55·10	34·80	10·10	0·0019
4	Helada ...	5	55·41	34·30	10·29	0·0007
5	Paloma ...	10	57·78	34·30	7·92	0·0017
6	Blancita ...	18	54·22	33·80	11·98	0·0009
7	Pacho ...	1	59·61	33·33	7·06	0·0029
8	Cajon Amarillo ...	—	56·11	33·30	10·59	0·0030
9	Negrita ...	12	59·31	31·10	9·59	0·0010
10	Helada ...	6	56·93	29·90	13·17	0·0019
11	Negrita ...	11	61·43	27·70	10·87	0·0020
12	Cenaguera ...	23	67·21	25·00	7·79	0·0014
13	Montera ...	28	71·42	25·00	3·58	0·0009
14	Negrita ...	17	60·57	23·90	15·53	0·0035
15	Pacho ...	3	58·57	22·30	19·13	0·0022
16	Pacho ...	2	72·28	22·10	5·62	0·0010
17	Pacho ...	4	64·19	19·30	16·50	0·0010
	Average ...		60·12	29·53	13·6	0·0010

MEMORANDUM.

BY ROBERT THOMSON.

The varieties analysed were collected in various provinces of the republic of Colombia last year by my son, under my instructions. These are new to the West Indies. I resided many years in that republic, and the importance of this culture attracted my attention, consequent on the enormous consumption of cassava as an article of human food—cooked in the same way as Irish potatos. Indeed, some of the varieties of cassava, I concluded, were equal in point of flavour to that tuber. I was also struck with the capacity of the plant to resist droughts. Poisonous varieties are unknown to the people in the interior of Colombia, so that the people there entertain no shadow of suspicion in this respect.

Only a few cuttings of each variety were introduced, and these were planted only about a foot apart in nursery beds, with a view to subsequent propagation on a large scale I now have cuttings enough to plant about two acres. I regret I have been unable to establish experiment plots of each variety with a view to test their respective productive capacity on the hot plains. Some of the varieties succeed best on the hills.

The result of the analyses of the seventeen varieties is important. The leading variety contains the extraordinary percentage of 36·50 of starch. Other varieties closely approximate to this.

From plants systematically cultivated in the field here and planted contemporaneously with the Colombian varieties the return which I have obtained is only 17 per cent. Doubtless by chemical analysis the yield would be somewhat higher.

From the point of view of human and animal food the analysis is also extremely important. As is stated by Mr. Cousins, the poisonous bitter cassava grown in Trinidad contains 0·022 per cent. of hydrocyanic acid, and the sweet 0·010 per cent. Thus the sweet actually contains nearly half of the hydrocyanic acid of the bitter. The contrast in this respect with the Colombian varieties is remarkable. Mr. Cousins says: 'The average obtained for these Colombian varieties is only 0·0017 or only one-sixth the amount contained in Trinidad sweet cassava.'

The general result is that the Colombian varieties are *par excellence* the varieties to be cultivated for animal food, as well as for starch production.

CULTIVATION AND PREPARATION OF GINGER.

The following summary of a paper by the late M. G. Landes on the Cultivation and Preparation of Ginger is taken from the *Pharmaceutical Journal* for March 14, 1903. The original paper appeared in the *Journal d'Agriculture Tropicale*, Vol. II, p. 204 :—

The soil intended for planting with ginger should be well tilled and carefully weeded. This should be done before planting, for if much weeding be performed while the crop is growing water may come in contact with the rhizomes and cause them to rot. After planting, the soil is covered with banana fibre and farmyard manure. In dry situations irrigation must be resorted to, to ensure the requisite amount of moisture; in damp situations the soil must be carefully drained, for stagnant water is fatal to successful culture, the ginger under such circumstances being attacked by black rot, and the rhizomes acquire a bad odour and flavour. Commercial ginger consists solely of the rhizome, which must not be confused with the true root. The most esteemed ginger is that which has these rhizomes in the form of straight 'fingers' regularly developed. This well-formed growth can only be obtained in soil which has previously been well worked. The harvest takes place as soon as the stems of the plant turn white. If left after this period the rhizomes throw up aerial stems, and become tough and fibrous. The rhizomes must be lifted by a single thrust of a fork, so as to dig up the entire piece, all breaking and bruising being carefully avoided; this alone requires much practice to effect with precision. All adherent soil is at once carefully removed, together with the fibrous roots; if these be allowed to dry, the pieces of ginger cannot afterwards be obtained white, and are liable to become mouldy. They are then at once thrown into water and peeled. This peeling must be most carefully conducted, only the epidermis being removed, since the cells immediately beneath it are richest in essential oil and resin. This operation is generally conducted with a narrow-bladed, sharp-pointed knife, but some expert peelers use only the fingers. As soon as they are peeled the rhizomes are thrown into water, which should be frequently changed if the ginger is to be of the best colour. The pieces peeled during the day are left in the water during the following night. Some planters add lime juice to this maceration water in order to obtain a white ginger, but the product thus treated is more subject to attacks of mould than that treated with water alone. Citric acid or vinegar might with advantage be substituted for lime juice. Another method is to throw the unpeeled ginger into boiling water, but the result is not so satisfactory as that obtained by cold maceration; although subequent peeling is easier, this method is not employed in Jamaica. If boiling be prolonged the ginger becomes dark in colour, and when dried forms the so-called black ginger. When the ginger after drying is not perfectly white it is sometimes coated with chalk; sulphurous acid or bleaching powder are also sometimes used to bleach the product, but such chemical treatment is not to be

recommended. After washing, the ginger is dried in the sun. On the large scale this is done in a 'barbecue,' a paved and cemented surface slightly convex, situated so as to obtain the maximum exposure to the solar rays. Small planters use a drying hurdle, formed of pieces of wood placed side by side and covered with banana or palm leaves. The ginger should be carefully turned over during the process of drying at least once daily. Six or eight days are generally required for the process, during which the ginger loses about 70 per cent. of its weight. Good ginger still retains 7 to 12 per cent. of moisture, as shown by drying at 100° C., but in badly dried specimens this may amount to 25 per cent. In some seasons this sun drying cannot be carried out, and the whole crop is, therefore, lost in consequence of attacks of mould. Attempts have been made to dry ginger without peeling it, but the product is black and worthless. The same ill success has attended the use of a desiccator, such as is used for fruit in North America. In China a totally different method of procedure is adopted. The ginger is rasped, so that it is obtained in the form of a powder, which is then dried and used [by the Chinese] as a condiment.

GAMBIER IN THE WEST INDIES.

(*Uncaria Gambier*, Roxb.)

Gambier is a valuable tanning material obtained from the leaves of a plant (*Uncaria Gambier*, Roxb.) cultivated largely in the Straits Settlements. About twelve years ago an effort was made to introduce the cultivation of gambier into the West Indies. In view of the fact that the possibility of gambier cultivation in these colonies has recently been discussed, it seems advisable to bring together a brief account of the gambier plant, and of the result of the attempt to introduce it into the West Indies. The following notes are taken from the volumes of the *Kew Bulletin*, from 1889 to 1903, where the experiments in question are described in detail:—

'The gambier plant is a strong shrubby climber, with opposite leaves, and with numerous small flowers closely crowded on small globular receptacles. The peduncles on which the flowers are borne are of singular structure, and after the fall of the inflorescence the lower portions become elongated, very hard, and curved into hooks by which the plant climbs. Sometimes these curious axillary hooks are produced without bearing any heads of flowers. The numerous seeds are very minute, and with a long transparent tail at each end. The plant is found wild or cultivated in Malacca, Penang, and Singapore, and also in Java and Sumatra.'

Gambier is obtained by boiling the leaves of the plant, and appears in commerce as an 'earthy looking substance, of light brown, and sometimes of a yellow hue, consisting of cubes about an inch each side more or less agglutinated: it is

sometimes in flat cakes or in the form of entirely compact masses.'

The principal use of gambier is for tanning and dyeing, but the finer qualities are also employed in medicine, having valuable astringent properties.

INTRODUCTION TO THE WEST INDIES.

In 1889 inquiry was made of the Royal Botanic Gardens, Kew, as to the possibility of extending gambier cultivation, owing to the increasing scarcity of material of good quality in the market. Opportunity was taken of the visit of Dr. Morris, then Assistant Director of Kew, to the West Indies in 1890, to attempt the introduction of gambier into these colonies. The following account, taken from the *Kew Bulletin* 1891, pp. 109-10, describes this experiment. Incidentally, also, there is given the result of an experiment, then carried out, in keeping delicate plants in good order on board ship, by the use of the electric light:—

'The present attempt to introduce the cultivation of gambier into the West Indies is a fact of some interest. It was only possible to arrive, thus far, in the matter after several years of persistent effort. The gambier industry had hitherto been entirely confined to the East Indies, but owing to the increased demand due to American consumption, and the deterioration in quality which had obtained of late years, it was felt desirable to extend its culture to other parts of the tropics. The effort made to place these plants at the disposal of those who may be inclined to cultivate them in the West India islands is only a part of the general policy pursued at Kew for many years. The plants in the first instance were proposed to be entrusted to the botanical establishments in the West Indies to be propagated and distributed.

USE OF ELECTRIC LIGHT ON BOARD SHIP.

'Owing to the cold weather the cases on board the *Atrato* were placed below in the main saloon. There was very little direct light in the day time, but the question of warmth was for the moment of more importance than that of light. It was also hoped that they could be placed on deck in a day or two at the most. The weather during the whole of the first week, however, continued very cold, and it was impossible to expose the plants on deck. Under these circumstances it was fortunate that the electric light, with which every part of the ship was supplied, was available to try an experiment of some interest. Although the plants received very little light during the day, they had a good supply of electric light during the night, and the particular plants that were more fully exposed to the electric light were afterwards found to be in a much better condition than the others. It is well known that plants will thrive under the influence of artificial light, but in this instance there was so little direct light available during the day that the plants had to depend almost entirely on the light they received at night. The gambier plants are particularly sensitive as regards a diminution of light. During the

prevalence of fogs at Kew they have been known to drop their leaves within a day or two, and to remain bare during the rest of the winter. This may have been in some measure also due to the injurious influence of the fog itself.

'In the present instance the plants were placed below on November 12, and were removed on deck on November 19. They had been below exactly one week. On deck they were placed on a hatchway on the starboard side, and shaded from the direct rays of the sun by an awning.

'In order to make myself acquainted with the exact condition of the plants before they left my charge, the cases were opened on November 22, about thirty-six hours before arriving at Barbados. All the plants were in good order; a few, it is true, had lost their leaves, but the greater number were in excellent condition. The case in which the plants had suffered most was one of the two intended for the Jamaica gardens. This had been placed with its end towards the electric light, and, in consequence, had received less direct light than the others.

'The use of electric light for the safe transit of such valuable plants as are obliged to be despatched from this country during the winter months is evidently capable of being greatly extended. It may also be utilized in the case of tropical plants arriving in this country from abroad, during the prevalence of cold weather. Such plants could be placed below directly the weather is becoming too cold for them on deck, and then the more electric light they have the better.

DISTRIBUTION IN THE WEST INDIES.

'The *Atrato* arrived at Barbados on the morning of November 24. The cases for St. Vincent and Trinidad were transhipped on board the *Eden*; the case for Demerara was transhipped to the *Esk*; the case for Dominica was transhipped to the *Solent*; while the cases for Jamaica remained on the *Atrato*, to go on direct to Kingston. The cases that were transhipped were carefully handled under the supervision of Mr. [now Commander] Owen, the chief officer of the *Atrato*, and my personal thanks are due to Captain Brander and to this officer for the great interest they took in this valuable consignment of plants, and for the facilities afforded for their careful treatment during the voyage.

'The reports received respecting the gambier plants on arriving at their destination were as follows:—*Jamaica, December 1*: 'Thirty-four plants in good order, eight in fair order, thirty-eight somewhat weak;' *British Guiana, December 3*: 'The plants arrived safely, all living;' *Trinidad, December 17*: 'All the plants arrived safely, the lower portion growing freely;' *St Vincent, December 19*: 'Fifteen plants in good order, seven leafless, ten dead'—these plants were over-carried by the *Esk* to Trinidad and La Guayra, and returned to St. Vincent ten days late; *Dominica, November 28*: 'The plants arrived in good condition.'

The subsequent history of the plants is disappointing. In Trinidad, Dominica and British Guiana alone were the conditions at all favourable to their growth, and even in these three colonies the results, so far, are not such as to make it appear probable that gambier is a plant adapted for commercial cultivation in the West Indies.

TRINIDAD.

In the *Annual Report* for 1892 on the Royal Botanic Gardens, Trinidad, Mr. J. H. Hart, the Superintendent, says, the plants 'though promising at first have not thriven. They were tried in various positions but no plant has, up to the present, made such a start as will entitle us to look with confidence to their ultimate acclimatization.'

In 1893 the plants are reported as having 'taken a turn for the better, and one plant is flowering freely.' In the following year Mr. Hart writes: 'They have twice produced flowers without setting seed, but it is hoped that as they grow stronger, we may be able to secure good seed from them.' This hope, unfortunately, has not been realized, and gambier cannot yet be looked upon as likely to become a plant of economic importance in Trinidad.

DOMINICA.

In Dominica very similar difficulties were experienced as indicated by the following extract from the *Annual Report* for 1893 on the Botanic Station, Dominica, by Mr. J. Jones, the Curator:—'Of the case of gambier plants brought out by Dr. Morris in 1890 only four plants are now living. They are growing in one of the valleys on the St. Aroment estate. Plants distributed in other parts of the island failed. In November two of the plants flowered freely but no seed was produced. These plants may yet be acclimatized but the process is a slow one.'

BRITISH GUIANA.

In British Guiana the results were almost identical, as may be seen by the following extract from the *Report on the Botanic Gardens, and their work* for 1892-3, p. 13:—

'Of the Gambier plants introduced three years ago from Kew—all in bad health on arrival—two or three of the healthiest of those retained here lived for a year or so, one even flowering two or three times, none, however, at any season having shown healthy growth, all have perished now. Of the two given to Mr. im Thurn to try in the more salubrious climate of the forest region of the interior, and which he planted at his official residence at the Government Agency, Morawhanna, one died; but the other, Mr. im Thurn informs me, is healthy and grown into a spreading bush large enough to fill the interior of a good sized room, and that it flowers abundantly. This seems to indicate what was probable, that the moist climate of the forest region of the interior of Guiana is adapted to the requirements of gambier, and that with attention at first in procuring and

establishing the plants, it might be successfully grown there. It strikes from cuttings, and propagation on the spot might prove equally successful and a wide distribution be thus accomplished.

DIFFICULTIES IN ACCLIMATIZATION.

In the attempt to introduce gambier into the West Indies we have a good instance (exactly comparable to the attempts to introduce ipecacuanha from South America into the East Indies), of the difficulty often met with in the acclimatization of a new plant in any region. Had gambier been a plant from a temperate climate, the fact that it failed to thrive in the West Indies would not have been surprising. It is, however, a native of the warm, moist, tropical region of Singapore and Java, and, on theoretical grounds, might have been expected to find a congenial home in Trinidad, British Guiana and probably also Grenada and Dominica. In actual practice, this hope has not, as yet, been realized in spite of every care and attention. Some essential factor is apparently wanting in the natural conditions in the West Indies, in the absence of which gambier cannot thrive.

Too much stress should never be laid on adverse results obtained at Botanic Stations. These institutions do good work as nursery gardens in raising supplies of economic plants and for experiments with plants found to succeed in them. Botanic Stations are not necessarily typical of the general soil and climatic conditions of the country in which they are situated. In selecting the site of a Botanic Station many considerations have to be kept in view. For instance, it is necessary that the station should be so situated as to be of convenient access to members of the planting community of the whole colony, and not of any one particular district. This object is secured by locating the station near the principal town. In large colonies branch stations or gardens can sometimes be maintained in representative districts, as for example, at Jamaica. In small colonies this is not always practicable, however desirable. An effort has been made in this direction by the recent creation of small experiment stations scattered over the island as at Montserrat and St. Vincent, and for particular experiments such as cacao at Grenada, St. Lucia and Dominica, and sugar-cane at Barbados, Antigua, St. Kitt's and Nevis.

Had stations of this nature been in existence at the time when gambier was first introduced, congenial conditions in some of the islands might have been found. Some foundation for this hope is found in the fact that, the plants sent to Dominica did so much better at St. Aroment, further inland, than at the Botanic Station, and yet these two localities are less than two miles apart.

The fact that gambier did comparatively well with Mr. im Thurn at Morawhanna in the North-west district of British Guiana affords additional evidence for this belief.

In summing up we may regard the results of efforts to cultivate gambier in the West Indies, so far, as purely negative.

They do not, necessarily, mean that all hope must be abandoned of gambier becoming, at some future date, a plant of economic importance in this part of the world. All we can say, at present, is that we have not yet found exactly the right conditions here for its successful cultivation.

AGRICULTURAL PROGRESS AT BERMUDA.

The interesting colony of Bermuda is outside the tropics, and is not usually regarded as a part of the West Indies. It is situated in mid-ocean at almost equal distances from the West Indies, the eastern sea-board of the United States, and the Dominion of Canada. It is composed of a group of about 300 small islands with a total area (according to the *Colonial Office List*, 1902, p. 77) of about eighteen square miles—less than one-eighth the size of Rutland and about one-ninth that of Barbados.

The largest island, generally known as the Main Island, is about fourteen miles in length and about a mile in average width. It contains about 9,000 acres of land, the highest point being only 240 feet above the sea. All the other islands taken together measure about 3,000 acres. The city of Hamilton, now the seat of Government, is situated about the middle of Main Island where a deep inlet, running up for two or three miles juts into the land from the sheltered waters enclosed between the encircling reefs, and forms a safe and convenient harbour for the vessels carrying on the island trade. A little over one-third of the inhabitants (17,535) are of English descent, the remainder are black or coloured. English is universally spoken.

Owing to the large extent of rocky land, mostly covered with juniper cedars, and some swamps, the cultivable area in Bermuda is very small, probably not more than about one-fourth of the whole. But the climate, combined with the geographical position of Bermuda, in some measure compensates for the smallness of the area of fertile ground.

There being nothing to fear from winter frosts, the ground can be sown and planted at any time from the end of August to the end of March, and the crops can be gathered and shipped to New York in the middle of March, April, May and June, when the corresponding American produce has as yet scarcely shown itself above ground. The Bermudians, taking advantage of this, raise large crops of early potatos, onions and lily bulbs, tomatos and beet-root, with which they keep the New York market supplied at a time when those vegetables cannot be obtained from any other quarter. Small quantities of arrow-root and cut flowers are also exported. Practically the whole of the exports go to the United States, which in turn supplies two-thirds of the imports, the remainder coming from the United Kingdom and Canada.

The waters bordering the shores of Bermuda teem with excellent fish many of which, such as Red Snapper, Bream, Grunt, Mullet, Grouper, White-bait or Fry, are well known in the West Indies. The Green and Hawkesbill turtle are common. Whales are very occasionally seen off the coast. The only mammals are the rat, mouse and rabbit. The latter is said to have been introduced in 1661. The most attractive birds are the Red Bird, Blue Bird, Black-capped Mocking Bird, Humming Bird and Gold Finch. All native birds are carefully protected. The English sparrow was introduced from New York about 1874. Ten years afterwards about £530 was expended in an attempt to get rid of it, but without causing any appreciable decrease in its numbers.

Bermuda is important as a Naval Station (including a dockyard) for the West India and North American Fleet. The present garrison of Imperial troops numbers about 1,400 men and the mean number of the Admiralty establishment is 1,200.

Bermuda is also one of the ports of call for the steamers of the Canadian Line (Pickford & Black) connecting with the West Indies.

Latterly a good deal of interest has been taken with the view of improving the cultivation of the soil and promoting the agricultural interests of the colony. A board of agriculture has been formed and a Botanic Garden has been started with an experienced Superintendent for the purpose of introducing skilful methods of raising crops and educating the rising generation in the principles of sound husbandry.

There is little doubt that by the active co-operation of the Government with the leading landowners the area of cultivation can be still further extended and, also, that the crops raised may be such as will yield the largest possible returns to the cultivators.

The following correspondence will show some of the directions in which the Government is prepared to assist in developing the agricultural interests of the colony: —

Colonial Office—To Imperial Commissioner of Agriculture.

Downing Street,
December 4, 1902.

Sir,

I am directed to transmit to you for any observations which you may desire to make, the accompanying copy of a despatch from the Governor of Bermuda, suggesting that your assistance should be obtained in certain matters connected with agriculture in Bermuda.

2. I am also to transmit to you a copy of a despatch which was addressed to the Governors of British Honduras and Bahamas at the time of your appointment to be Imperial Commissioner and to inform you that, so far as you may have time there is no objection to your extending to Bermuda the advice and assistance which you give to these two colonies. but that, as the Parliamentary Vote for your Department

is specifically assigned for the benefit of certain colonies, among which Bermuda is not included, no assistance can be afforded to that Government which would involve a charge upon your Department, and as regards yourself, the claims of the colonies included in your scheme of work must take precedence of those of Bermuda.

I am, etc.,

(Sgd.) C. P. LUCAS.

The Governor of Bermuda—To the Secretary of State for the Colonies.

Bermuda,
November 12, 1902.

Sir,

I have the honour to inform you that Dr. D. Morris, C.M.G., the Imperial Commissioner for Agriculture in the West Indies, spent a day in this colony recently on his voyage from Halifax to the West Indies.

2. During his short stay at Hamilton, Dr. Morris evinced much interest in the work of the Public Garden, which is under the management of the Board of Agriculture, and every attempt was made to obtain his opinion on various matters connected with agriculture in these islands. I also consulted him with regard to an attempt which is being made, at my instigation, to encourage the teaching of elementary agricultural science to the teachers of the elementary schools and others in the colony.

3. Dr. Morris most willingly offered his advice on the several matters referred to him, and although the attempt recently made here to induce school teachers and others to attend lectures at the Public Garden was roughly on the lines which are being followed in the West Indies, Dr. Morris was good enough to point out some defects in the manner in which our experiment is being conducted.

4. Dr. Morris further expressed his readiness to endeavour to assist this colony directly with regard to one or two matters connected with agriculture, provided your consent be obtained to enable him to do so.

5. Although the Superintendent of the Public Garden has voluntarily consented to give lectures to the school teachers, I had, before Dr. Morris' visit, come to the conclusion that better results would be obtained were the services of some officer secured who had experience in such teaching, and who was specially qualified for such work. I consulted Dr. Morris on this point with a view to ascertaining whether the services of one of his staff could be secured for a short period during each year to give a course of lectures. Without making any promise that such a course could be followed, Dr. Morris undertook to give the matter his consideration, should you deem the proposal a practical one. This colony would, of course, pay the expenses of such an officer, and

should, in addition, remunerate him in any manner authorized by you.

6. I have had under consideration the desirability of recommending the Legislature to enact legislation with a view to protecting farmers against spurious manures that may be offered for sale in the local market, and I had proposed to suggest the passing of an Act somewhat on the lines of the Barbados law entitled 'The Fertilizers and Feeding Stuffs Act, 1894.' A difficulty arose in my mind as to the feasibility of making provision for obtaining proper and reliable analyses of manures for purposes of administering the law. Dr. Morris has suggested that such analyses, in the first instance, at least, may with your consent, be made by the staff of his Department on such arrangement as may be sanctioned.

7. I would also ask that, if possible, Dr. Morris should be authorized to furnish for the information of this Government, a memorandum supplying information in detail as to the code which he recommends for adoption for agricultural teaching in elementary schools in this colony, and in this connexion I have the honour to request that I may be informed whether any of the agricultural schools which have, I understand, been recently established by the Imperial Agricultural Department in the West Indies are open to students in this colony, and if so I shall be glad to receive information with regard to the terms on which students from this colony may be admitted thereto.

8. So soon as some settled and approved scheme is put in force to enable school teachers to acquire the necessary knowledge of elementary agricultural science, it is my intention to endeavour to persuade the Board of Education to offer additional grants to such teachers who qualify after examination and who add agricultural teaching to their school code, The House of Assembly have recently requested me to appoint a Commission to inquire into the working of the Schools Act and other matters connected with the education of the youth of the colony, and as it is requested further that the Commission shall offer suggestions to improve the present system, I shall endeavour to cause alterations to be suggested to the present code so as to include agricultural teaching in the elementary and other schools.

9. In conclusion, I cannot refrain from expressing my regret that this colony has not the advantage of the services of such an officer as the Imperial Commissioner of Agriculture for the West Indies as a recognized and official adviser in matters connected with agriculture, and if it can be found possible to give Dr. Morris some official connexion with the Botanic Station in Bermuda I feel confident that such an arrangement would find favour with the Legislature of this colony and with the large section of the population of these islands who are concerned in agriculture.

I have, etc.,

(Sgd.) H. LeG. GEARY,
Lieut-Genl., Governor and Commander-in-Chief.

Imperial Commissioner of Agriculture for the West Indies—To the Colonial Office.

Barbados,
March 25, 1903.

SIR,

I have the honour to acknowledge the receipt of your letter No. 48814/1902, dated December 4, 1902, enclosing for my observations a copy of a despatch from the Governor of Bermuda in which he suggests that my assistance might be invited in certain matters connected with the agriculture of the colony.

2. My recent visit to Bermuda was very interesting. I found that the members of the Board of Agriculture were closely in touch with the work carried on by this Department, and the Governor, the members of the Legislature, and others, were keenly anxious to carry on efforts on somewhat similar lines at Bermuda.

3. As you are aware, a Botanic Station was started at Hamilton a few years ago and an experienced English horticulturist (Mr. Geo. A. Bishop) was recommended by Kew to take charge of it. Unfortunately this officer was absent in the States and I had not an opportunity of meeting him. What I saw of his work at the Botanic Station impressed me favourably. It was distinctly economic in character and, I believe, on lines likely to be serviceable to the colony.

4. The cultivation of onions, potatos and lily bulbs carried on at Bermuda is a striking instance of what may be accomplished by energy and a careful study of local conditions. In an archipelago of rocky islands with a total area of eighteen square miles, the extent of cultivable land, distributed as it is in small patches, cannot be large, yet in some years the onion crop alone has reached an export value of £84,000. Bermuda is, in fact, the Jersey of the States, and with skill and intensive cultivation almost every square yard of land might yield crops of considerable value. What is desirable is to produce the choicest articles only, and to pack and ship them so that they arrive in New York in first-class condition and exactly at the right time.

5. As skilful agriculture must ultimately depend on the intelligence and aptitude of the people, the Governor is well advised to encourage the teaching of agricultural science in elementary schools. This should be regarded as the initial step in generally improving agricultural methods in the colony. Although the amount of agricultural information capable of being conveyed to children in elementary schools is small, especial care is necessary that both the teachers and scholars should regard the subject as an adjunct to general education and that a right understanding of the general principles of

agriculture is of greater value than the mere accumulation of facts connected with horticulture and gardening.

6. Although I am aware that Bermuda was not included in the proposals made by the West India Royal Commissioners and that it will be impossible, in any case, to afford pecuniary aid to it, I believe that something might be done to assist the Government in educational matters without detriment to the claims of other colonies.

7. Bermuda is now more accessible than either the Bahamas or British Honduras. There is direct communication by means of the Canadian Steamers once a fortnight. What I had in view when discussing the course of lectures to teachers and others at Bermuda was that Dr. Longfield Smith, the Lecturer in Agriculture at Barbados, might possibly undertake such a course during his vacation. At present, owing to quarantine against Barbados, nothing can be done. In the meantime the publications of the Department might be utilized as showing what is going on in these colonies.

8. Should a 'Fertilizers and Feeding Stuffs Act' be adopted and the Government desire to forward samples of manures and feeding stuffs to be analyzed by this Department, I believe this could be undertaken on payment of a fee in each case. The fact that manures and feeding stuffs sold at Bermuda would be liable to be analysed would in itself be a considerable protection to agriculturists. Few, if any, firms of good standing would care to run the risk of exposure in a matter of this kind. The essential point is that they should be required to furnish with the manures and feeding stuffs a certificate setting forth exactly the percentages of ingredients claimed to be contained in them.

9. The admission of students from Bermuda into the agricultural schools in the West Indies may be possible under certain circumstances. The cost per head, including everything, varies from, say, £30 at Dominica to about £38 per annum at St. Lucia. To this must be added the cost of return passages between Bermuda and the West Indies. I hope to make inquiry as to the accommodation at present available at the several schools and communicate, later, with the Government of Bermuda.

10. Whether the Commissioner of Agriculture could act as official adviser in matters connected with agriculture and have an official connexion with the Botanic Station at Bermuda, as suggested in the last paragraph of the Governor's letter, is a subject on which I hesitate to express an opinion at present.

11. The current demands on the time and attention of the Commissioner are considerable and they are daily increasing. I am reluctant to add to these demands outside the sphere of action originally laid down by the Royal Commissioners.

12. On the other hand, the publications of the Department are closely followed at Bermuda and as the people concerned in

agriculture are keenly anxious to develop the resources of the colony, I am prepared to do what I can to assist, but with due regard to the claims of the other colonies.

I have, etc.,

(Sgd.) D. MORRIS,
Commissioner of Agriculture
for the West Indies.

Imperial Commissioner of Agriculture for the West Indies—To Colonial Secretary, Bermuda.

Barbados,
March 25, 1903.

Sir,

I have the honour to enclose, herewith, for the information of the Governor, a copy of a letter I have addressed to the Under-Secretary of State for the Colonies in reply to his Excellency's despatch to the Secretary of State, No. 169 of November 12 last.

2. I regret that delay has taken place in dealing with the several subjects discussed in the despatch above referred to.

3. In the first place, after I left Bermuda, I was on tour in the West Indies for nearly two months and since my landing at Barbados I have been closely occupied with arrears of correspondence that had accumulated during my absence.

4. Further I regret to state that Barbados is still in quarantine and it has been impossible for me to make any arrangements whereby a Lecturer in Agriculture could proceed from here to Bermuda.

5. In regard to agricultural teaching in elementary schools I forward, herewith, a series of papers and publications that will afford a general idea of what is being attempted under the auspices of this Department in the West Indies.

6. I believe a careful perusal of these documents will be of service especially to the proposed Commission to inquire into the working of the 'Schools Act' and other matters connected with the education of youth in the colony.

7. The ultimate decision in regard to the degree and character of the assistance that could be afforded by this Department to Bermuda rests with the Secretary of State for the Colonies, but speaking for myself it will afford me pleasure to render such service as may be within my power in connexion with the agricultural development of the colony.

I have, etc.,

(Sgd.) D. MORRIS,
Commissioner of Agriculture
for the West Indies.

NOTES ON FALL OF VOLCANIC DUST AT BARBADOS, MARCH 22, 1903.

In a former number of this journal an account has been given of the falls of volcanic dust at Barbados following the eruptions of the Soufrière of St. Vincent on May 7, and October 15, 1902 (*West Indian Bulletin*, Vol. III, pp. 281-93.)

Several eruptions of the Soufrière have since taken place but no further showers of dust have been experienced at Barbados until March 22.

The following letter, received from Mr. H. Powell, Curator of the Botanic Station, St. Vincent, gives some interesting details respecting the phenomena witnessed at Kingstown about twelve miles from the Soufrière:—

'I have to report a serious eruption of the Soufrière on Sunday last the 22nd. instant.

The clouds of stones, ashes, etc., were of stupendous size and rose to an enormous height, somewhat similar to those of May 7 last. The noise on the 22nd. was, however, far less than on May 7, and the electric display was not so marked.

At 11.30 a.m. and again at 12.30 p.m., on the 21st. instant [that is, the day before the eruption] huge volumes of vapour were seen ascending from the crater and at about 6.30 on the morning of the 22nd. the eruption commenced, and continued during the morning and most of the afternoon. At 9 a.m. on the 23rd. there was another huge outburst.

On the 22nd. a slight layer of dust fell at the Botanic Station (near Kingstown) and the northern half of the heavens was shrouded in gloom, but there was no real darkness.

The cloud of dust was observed going in the direction of Barbados, so that cable news of darkness occurring in that island did not come as a surprise.

Hall, the man in charge of the Experiment Station at Georgetown, has informed me by telephone that very serious damage has been done to the experiment plots there. He reports having carefully measured the new deposit; he finds it about 3 inches in thickness with numerous stones almost the size of one's fist.

I am visiting the Windward District this week and will report the result of my inspection.

At "Tourama," north of Georgetown, 5 inches of ejecta are reported; but at "Colonarie," some distance to the south of Georgetown, the layer is said to be light.'

OBSERVATIONS AT BARBADOS.

The Rev. N. B. Watson, Vicar of St. Martin's, Barbados, made observations at his residence situated on the windward

side of the island, about twelve miles east of Bridgetown. His interesting notes are reproduced in full :—

Sunday, March 22, 1903.

8 a.m.	Two detonations heard here by several persons shortly after 8 a.m. I did not observe them.
9 a.m.	Horizon at W. obscured. Dark blue cloud at W. moving to E. Prevailing wind[1] E. Edge of western cloud about 45°. Base of cloud extends from W.N.W. to S.W. by W.
9.15 a.m.	Cloud approaching with apparently increased rapidity. Its northern edge hard ; from about 50° W., regular and less defined ; below 50° edge hazy. Eastern, or approaching edge, about 70° from W. irregular, rolled and cumulose. Light fleecy clouds moving quickly to W.
10 a.m.	Dust cloud flabelliform, with smaller area at W. Its edge at N. 20°, S. 40°, E. 135°, from W. Southern edge tinged with yellowish-red, horizon below that yellowish-green. Distant objects at W. slightly obscured. Temperature 79° F. Sun obscured.
11 a.m.	Horizon clear from N. to S. by E. Edge of cloud at N. and S. well defined and regular, eastern edge hard and sinuate. Highest at N. 15°, S. 10°, E. 15°. Growing dark. Cloud becoming intensely blue-black.
11.35 a.m.	Dust first reached earth here. Particles of dust free, coarse, and much darker than fall of May or October, 1902. Growing intensely dark. Horizon from N.E. to S.E. clear, but lurid from N. E. to N.N.W., and from S.E. to S. by W.
11.49 am.	Growing very dark. Cloud intensely blue-black.
12 p.m.	Intensely dark. Temperature 79° F. Horizon at W. obscured from N.N.W. to S. by W. From these points, eastward, cloud edge 10° from horizon. Wind lighter.[2] Dust cloud denser at S.W. than at any other point. Sun totally obscured. Atmosphere slightly sulphurous. No electrical display.
12.15 p.m.	Less dark than at 12 noon. Only part of horizon not obscured is from N. to N.E.
12.30 p.m.	Lighter. Sky of a reddish-brown colour. Whole horizon obscured. Hills of St. John's, three and a half miles off, now obscured. Cabbage palms at Kirton, three-quarters of a mile off, still visible. Dust accumulating in drifts. General effect not wintry as in May and October, 1902.
12.35 p.m.	Fall of dust from 11.35 a.m. to 12.35 p.m. 5·79 grammes per square foot.
1 p.m.	Sunlight sufficient to cast a feeble shadow—sun can be observed without pain to the eye. Wind calmer[2]. Hills of St. John's quite obscured. Less dust falling than in May or October, 1902. Up to

	the present there is an absence of that hushed calm so noticeable in the October fall. Dust appears to contain large percentage of iron; if mixed with water gives the latter a rusty colour.
1.35 p.m.	Fall of dust per square foot from 12.35 to 1.35 p.m. 11·49 grammes. Sky less brown and more of a yellowish red.
2 p.m.	Much lighter. Dust fall slight. Sky colour ferruginous. Wind calm[1]. Temperature $79\frac{1}{2}°$ F. Distant objects still obscured.
2.35 p.m.	Fall of dust per square foot from 1.35 p.m. to 2.35 p.m. 7·30 grammes. Dust cloud less dense. Wind calm[1].
3 p.m.	Light breeze[3] from E.N.E. Less dense at N.
3.35 p.m.	Fall of dust from 2.35 p.m. to 3.35 p.m. 4·50 grammes per square foot. Sky still overcast. Temperature $79\frac{1}{2}°$ F.
4 p.m.	Fall of dust very slight now. Sky less dense especially at N.
4.35 p.m.	Fall of dust per square foot from 3.35 p.m. to 4.35 p.m. per square foot 0·42 grammes. Light blue sky appearing at N.W.
5.35 p.m.	Fall of dust from 4·35 p.m. to 5.35 p.m. per square foot 0·62 grammes.
6 p.m.	Fall of dust almost imperceptible. Sky clearing. Cumulus clouds at S. of a lovely light-blue colour. Horizon and sky light glare of red. Sunset ordinary.
9 p.m.	Fall of dust from 5·35 p.m. to 9 p.m. 0·58 grammes.

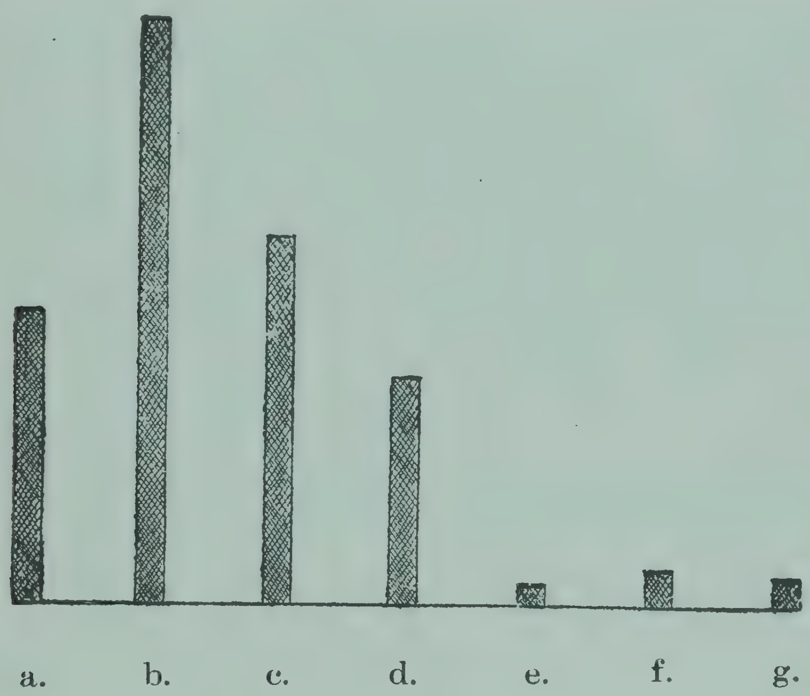
Hourly fall at St. Martin's Vicarage, St. Philip.

a.	11.35 a.m.	to	12.35 p.m.	...	5·79	grms.
b.	12.35 p.m.	,,	1.35 p.m.	...	11·49	,,
c.	1.35 p.m.	,,	2.35 p.m.	...	7·30	,,
d.	2.35 p.m.	,,	3.35 p.m.	...	4·50	,,
e.	3.35 p.m.	,,	4.35 p.m.	...	0·42	,,
f.	4.35 p.m.	,,	5.35 p.m.	...	0·62	,,
g.	5.35 p.m.	,,	9.00 p.m.	...	0·58	,,
	Total 11.35 a.m. to 9 p.m.			...	30·70	grms.

The calculations in the case of the fall of dust at St. Martin's Vicarage would indicate that the total fall there was at the rate of 2,912 lb. per acre. As was to be expected less dust fell per acre in the windward or eastern districts of Barbados, (that is in districts furthest away from St. Vincent) than in the leeward or western districts. It may be mentioned here that it would have been of considerable interest if careful observations, similar to those carried out by the Rev. N. B. Watson, had been carried out in other parts of Barbados especially in the parishes of St. James, St. Peter and St. Lucy.

Only one case is recorded of observation of the fall of dust at sea. This was on Sunday morning, the 22nd, by the captain of a schooner 80 miles to the south-east of Barbados. No particulars of the actual fall are available.

In the following diagram an attempt is made to illustrate the relative amount of dust that fell at St. Martin's Vicarage during each hour from 11.35 a.m. to 9 p.m. The very much larger amount that fell during the second hour is strikingly shown. This corresponds with the results obtained by Dr. Morris at Chelston near Bridgetown (See p. 96).



HOURLY FALL OF VOLCANIC DUST.

The length of the columns, a-g, represents the relative quantities of dust which fell per hour at St. Martin's Vicarage, as given in the table opposite.

The fall at Bay Mansion, Bridgetown, at the south-east corner of the island, was carefully observed by Dr. J. W. Spencer, M.A., F.G.S., who has kindly supplied the following account:—

'The cloud of volcanic dust reached the zenith at about 9 a.m., this gives the cloud a velocity of over forty miles per

hour. The cloud was of a deep Prussian blue colour, and was so dense as to cut off all direct light from the sun. As the cloud advanced it became more grey and covered the horizon with the exception of a narrow zone to the east, this was also obscured about noon, but simultaneously the light began to penetrate the cloud in the region of the sun. The darkness was so intense, just before this time, that it was impossible to read even large type. The fall of dust began about 11.15 a.m. and increased till 1.30 p.m., when the quantity steadily diminished till it was hardly perceptible at 5 p.m. The ashes were dark grey in colour. The cloud, as it advanced towards Bridgetown, came in a direction opposite to the prevailing wind at the time. The axis was apparently from a point a little north of St. Vincent, suggesting that the cloud was first carried northwards, and then east. The cloud also appeared much denser towards the north and completely covered the northern horizon before it obscured the southern. The height of the cloud as it reached here was about 8,000 feet or double the height of the Soufrière, but after the ashes began to fall the lower strata were at a much less height; probably at St. Vincent the cloud was three miles high. The quantity that fell was about 6,000℔. to the acre.

Another careful estimate of the fall was made at Chelston, the residence of Dr. D. Morris, C.M.G.

Two sheets were placed on a lawn at the commencement of the shower, and at the end of each hour were brought in and two other sheets put in their place, and so on throughout the continuance of the shower. The dimensions of each of the sheets used was $2\frac{1}{2}$ yards by 2 yards. The weight of dust which fell per hour on ten square yards was thus obtained. The figures are as follows :—

	Fall of Dust on 10 sq. yards.
11.15 a.m. to 12.30 p.m.	3℔. 5oz.
12.30 p.m. to 1.25 p.m.	5℔. 12oz.
1.25 p.m. to 2.30 p.m.	2℔. 12oz.
2.30 p.m. to 4 p.m.	13oz.
Total 11.15 a.m. to 4 p.m. ...	12℔. 10oz.

This result is in close agreement with that of Dr. Spencer, and gives an estimated fall, per acre, of $6,110\frac{1}{2}$℔.

As in the Rev. N. B. Watson's observations the greatest fall was obtained during the second hour.

At Codrington House, about two miles north of Bridgetown, notes on the fall of the dust were made by Mr. J. R. Bovell, and Mr. W. G. Freeman. These observers collected the hourly fall on wooden trays, each exactly eighteen inches square, with

vertical sides three inches high. The results obtained were as follows :—

		Fall on $2\frac{1}{4}$ sq. feet.
11.15 a.m. to 12.15 p.m.	...	103·5 grms.
12.15 p.m. to 1.15 p.m.	...	76·9 ,,
1.15 p.m. to 2.15 p.m.	...	50·5 ,,
2.15 p.m. to 3.15 p.m.	...	67·8 ,,
3.15 p.m. to 4.15 p.m.	...	44·4 ,,
	Total	343·1 grms.

The fall recorded at Codrington House is extraordinarily high compared with that at Chelston or at Bay Mansion, the figures above indicating a fall of dust at the rate of 6 tons 11 cwts. per acre.

The maximum fall, it is worthy of notice, was here experienced during the first hour, whereas at Chelston the fall during the first hour occupied the second place, and at St. Martin's was third in order.

At Codrington it was noticed also that the leaves of the Guango or Rain tree (*Pithecolobium Saman*), which exhibit regularly the phenomenon known as the 'sleep' of plants, had assumed their night position by noon.

At Atlantis Hotel, Bathsheba, on the windward coast, about fourteen miles north-east of Bridgetown, the cloud was first noted at 9 a.m. in the south to south-west. It was then of a dark blue colour. The first dust fell at 11.15 a.m., the colour of the cloud had by this time changed to a rusty brown. At no time was it so dark that artificial lights were necessary in the hotel. Apparently the fall of dust was considerably less than at Bridgetown.

Prof. J. P. d'Albuquerque, M.A., F.I.C., F.L.S., Island Professor of Chemistry, Barbados, has contributed the following report, containing the results of chemical and mineralogical analyses and other notes.

The samples of dust analysed were collected at the Government Laboratory, Bridgetown :—

MECHANICAL ANALYSIS.

Diameter of Particles.

3 mm. to 1 mm.	...	...	...	None
1 ,, ,, 0·5 ,,	...	...	...	None
0·5 ,, ,, 0·25 ,,	...	...	...	11·3
0·25 ,, ,, 0·05 ,,	...	...	...	81·3
0·05 ,, ,, 0·01 ,,	...	...	...	3·5
0·01 ,, ,, 0·002 ,,	...	...	...	2·4
0·002 ——	...	...	...	1·5
				100·0

CHEMICAL ANALYSIS.

Moisture	·130
Loss on ignition	·545
Potassium oxide	5·31
Sodium oxide	3·451
Calcium oxide	10·100
Magnesia	5·911
Manganese oxide	·450
Alumina	12·550
Ferrous oxide	4·676
Ferric oxide	9·484
Titanium oxide	1·150
Phosphoric anhydride	·192
Sulphuric anhydride	·108
Carbonic anhydride	—
Silica (by difference)	50·722
	100·000

Soluble in hydrochloric acid (Sp. Gr. 1·115).

Potassium oxide	·070
Sodium oxide	1·007
Calcium oxide	5·520
Magnesia	2·869
Manganese oxide	—
Alumina	10·360
Ferrous oxide	1·886
Ferric oxide	2·304
Titanium oxide	·192
Phosphoric anhydride	—
Sulphuric anhydride	·108
Carbonic anhydride	—
Silica	·182

This material has, in my opinion, no fertilizing value for Barbados soils.

(Sgd.) J. P. d'ALBUQUERQUE,
Island Professor of Chemistry and
Agricultural Science.

MINERALOGICAL ANALYSIS.

The dust is of a coarse character, the majority of the grains varying in diameter from ·25 to ·05 millimeter. A few particles have a diameter as great as 4 mm. There is a marked difference in the texture of the samples collected during different intervals, the coarsest particles falling during the first hour and the finest, last.

The following observations were made on the size of the particles:—

Time when collected.		Average diameter of particles.
11.20 a.m. to 12.20 p.m.	...	·25 to ·17 millimeter.
12.20 p.m. to 1.40 p.m.	...	·2 to ·15 ,,
1.40 p.m. to 2.40 p.m.	...	·17 to ·13 ,,
2.40 p.m. to 3.30 p.m.	...	·12 to ·09 ,,

The minerals present are the same as those found in the preceding dustfalls, though the relative proportions differ very considerably. As in the dustfalls of last year there is very little glass.

The most striking feature about the present dustfall, which at once distinguishes it from the former dusts, is the large amount of magnetite and haematite which is present. By means of a weak magnet slightly over 4 per cent. of the particles were readily separated, and an electro-magnet separated fairly readily over 3 per cent. more.

Of the particles separated by a weak magnet only a small percentage sank in methylene iodide, that is, had a specific gravity of over 3·3, showing that the magnetite was mixed with a considerable proportion of other minerals. Examined under a miscroscope the particles which sank in methylene iodide were found to consist of a few simple grains of magnetite, but chiefly of pyroxenes enclosing magnetite. The lighter particles which floated in methylene iodide were found to consist of mixtures of haematite and magnetite enclosed in fragments of glass and felspar, the glass and felspar having numerous tiny gas bubbles enclosed in them which made the particles float.

Of the particles separated by an electro-magnet none had a specific gravity over 3·3. They were of similar nature to the lighter particles separated by the simple magnet, only they appeared to contain less magnetite and more haematite.

Of the particles not separated even by an electro-magnet a large number were quite opaque owing to included haematite.

The proportion of ferro-magnesian minerals appears considerably less than the amount present in the dust of May 7, 1902. The predominant ferro-magnesian mineral is a light green variety of augite frequently enclosing grains of magnetite. Some of the monoclinic pyroxene grains are perfectly clear and colourless (malacolite ?). There is a considerable proportion of hypersthene.

The felspars are plagioclases, and largely of the lime-soda variety. They exhibit marked zonal structure, and many of them contain numerous minute gas bubbles arranged in lines or zonally.

There is only a small proportion of glass, and this is of two kinds—a clear, colourless to brown variety, and a translucent

to opaque variety which is often brown owing to numerous haematite inclusions. The clear glass encloses microlites, and often crystals of felspar.

(Sgd.) LONGFIELD SMITH,
Lecturer in Agricultural Science.

Record of the fall of Volcanic Dust at the Government Laboratory, Barbados, on March 22, 1903.

11.20 a.m. to 12.20 p.m.	... ...	1·00	tons per acre
12.20 p.m. to 1.40 p.m.	... ...	1·67	„
1.40 p.m. to 2.40 p.m.	... ...	·65	„
2.40 p.m. to 3.30 p.m.	... ...	·20	„
Total fall	... ...	3·52	„

(Sgd.) E. GILLMAN,
Chief Assistant.

GROUND NUTS IN THE WEST INDIES.

BY WILLIAM G. FREEMAN, A.R.C.S., B.Sc., F.L.S.

Scientific Assistant, Imperial Department of Agriculture for the West Indies.

The ground nut, known also by a variety of other names such as earth nut, pea nut, monkey nut, pindar and *pistache* (Martinique and Guadeloupe), *Erdnuss* and *Erdiechel* (German), is the fruit of *Arachis hypogaea*, Linn., an annual trailing plant of the Leguminous order (*Leguminosae*). The ground nut is now grown throughout the tropics, the United States and in Southern Europe. It has been cultivated for such a long period that no records exist as to its native country and indirect evidence has to be sought. The genus *Arachis* contains but seven species, and six of these are definitely known to be natives of Brazil. This and other evidence points to Brazil being the native country of the ground nut, the only other member of the genus. The plant is remarkable for its habit of burying its seed pods in the ground to ripen. This fact, whilst of interest from a natural history point of view, is also of economic importance, as it increases very considerably the cost of harvesting the crop.

The general characters of foliage, flower and fruit are sufficiently well indicated in the accompanying illustration. The plant naturally trails on the surface of the ground. In some varieties the pods are borne along the trailing branches or vines, whilst in others they occur mainly at the base of the main stem. This apparently unimportant difference is also of economic value, as the varieties bearing pods along the vines are more troublesome to harvest than the others.

Ground nuts are cultivated to a limited extent in various parts of the West Indies. At present they are grown mainly for their value as an article of diet, whilst their more important use as a source of oil for cooking purposes and as a source of

oil-cake is practically ignored. In view of the very large importation of oil, oil-cake and oil-meal into these colonies, it would seem that more attention might be given to the cultivation of this plant, not necessarily in the first instance for export purposes but to satisfy home demands and to help, to some degree, towards that self-support which has so often been urged on West Indian planters, as one of their first duties in the present period of depression.

THE GROUND NUT *(Arachis hypogaea).*
[From the *Dictionary of Gardening.*]

The objects of this paper are (1) to bring together the ascertained facts relative to the cultivation and use of the ground nut as at present practised in the West Indies; (2) to describe the uses made of the plant in the West Indies and also in other parts of the world; (3) to endeavour to indicate how the locally grown ground nut might be utilized to replace some of the expensive imported oil-meals, etc.; (4) to discuss the value of ground nuts as an article of export.

PRESENT CONDITION OF INDUSTRY IN WEST INDIES.

Trinidad: 'Good ground nuts have been grown in Trinidad and have frequently been shown at our exhibitions of produce, but nevertheless the market is principally supplied with produce which is of American growth.' (*Bulletin, Royal Botanic Gardens, Trinidad,* Vol. II, p. 125.)

Grenada: Mr. W. E. Broadway, Curator of the Botanic Station, writes that he knows of no place in the island where ground nuts are cultivated. A considerable industry, however, is carried on at Carriacou (one of the Grenadines), a small island between Grenada and St. Vincent, whence they are exported. The nuts are eaten parched, made into sweetmeats, etc.

St. Vincent: Ground nuts are grown to some extent in St. Vincent, and succeed well in the light, rich, volcanic soils found over a great portion of the island.

St. Lucia: Ground nuts are eaten in the island and for this purpose are imported from the United States and from other West Indian islands.

Barbados: A considerable 'minor industry' is carried on in the colony. The nuts are mainly grown on the poor calcareous soil of St. Philip parish on the windward coast. The cultivation is almost entirely in the hands of small holders who grow the plant amongst others. The largest grower in the island cultivates some two acres only in this crop. The nuts are parched and sold by hucksters in the streets for eating purposes and they are also employed in nut cakes, etc.*

Dominica: Ground nuts are not cultivated to any extent in the island. According to information obtained by Mr. J. Jones, the Curator of the Dominica Botanic Station, they are grown here and there on a small scale, and used for roasting and making nut cakes.

Antigua: Mr. W. N. Sands, the Curator of the Botanic Station, writes: 'There is no pea nut industry in Antigua. We tried several experiments with the hope of establishing a small industry, but our efforts were futile owing to persistent insect attacks.'

St. Kitt's: The plant is cultivated here and Mr. Lunt, the Curator, reports that the industry is mainly in the

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* See 'The Ground Nut Industry of Barbados,' *Agricultural News,* Vol. I, pp. 136-7.

hands of labourers on the leeward side of the island between Trinity and Palmetto Point and St. Paul's, and is seldom carried on by estates. He adds that it appears to be receiving less attention now than formerly. The annual crop is about 200 barrels. The produce is sold to hucksters and no attempt made to extract the oil.

Jamaica: Ground nuts are largely consumed in the colony but are not cultivated to any extent: the demand is met by importation. The extension of the industry in the island was advocated by Mr. Francis Watts in 1898. (*Journal Jamaica Agricultural Society*, Vol. II, p. 409.)

It is thus seen that in almost all the West Indian islands the ground nut is known and cultivated to a small extent, but in no case is it an important crop, nor are the most valuable properties of the plant made use of.

CULTIVATION.

Soil.—A light, well tilled soil appears the most suitable for the ground nut, and lime is apparently essential. When the nuts are intended for export, for dessert purposes, they should preferably be grown on a light-coloured soil: dark soils spoil the appearance of the husks, and lower the value of the nuts sometimes by as much as £4 per ton. Ground nuts thrive well on light, rich, volcanic soils in St. Vincent, on poor, friable, calcareous soils on the windward coast of Barbados, and on sandy soils at Carriacou. Good crops have also been obtained on heavy black land both in Barbados and Grenada, but in these cases the cost of harvesting the crop is very heavy.

Preparation of the Soil.—The land is usually well tilled, with hoe and fork, to a depth of about six inches. This is best done before the rainy season sets in. A supply of pen manure is often added, either immediately before sowing the ground nuts, or during the cultivation of a previous crop. One grower, for instance, in Barbados, practises a rotation of ground nuts and yams: he manures the ground well each time before planting yams, but does not directly manure the nuts.

Planting Season.—A moist condition of the ground being essential for the germination and the successful growth of the young plants, seed is usually sown before the onset of the rainy season. At St. Kitt's the plants meet with most success if planted in May, and in Barbados and Carriacou June is the usual month. On the other hand, Mr. L. C. Thorpe of Pointe Mulâtre, Dominica, reports good results from American seed sown in September, the crop being reaped in the following March.

Sowing.—The nuts are shelled and the seeds set from one to three feet apart, and about three inches deep. At Carriacou the widest planting is in vogue and the seeds are sown two together. At other localities they are usually sown singly, and closer together. Some cultivators soak the husked seeds for about two hours before planting, but this practice is not generally adopted. The seeds are covered with soil, lightly

pressed down by the foot and a little loose mould is sometimes raked over the impress of the foot to prevent the sun 'caking' the soil and hindering the spring of the young shoots.

Taking the medium spacing mentioned, eighteen inches, about 19,000 seeds would be required to the acre.

Care after Planting.—Beyond weeding, little attention is necessary. Fowls should be excluded when the seeds are germinating as they greedily eat the young shoots.

Time to Mature.—The ordinary variety cultivated in the West Indies takes from four to six months to ripen its fruits. Taking the average time of sowing to be June, the crop is usually ready between November and January. Some of the American varieties ripen in three months.

Harvesting the Crop.—The plants are dug up and the nuts picked off by hand. This method is laborious because the nuts occur along the trailing branches. The substitution of a variety bearing, as some do, their nuts chiefly at the base of the main stem would probably be advantageous.

Yield per Acre.—In Barbados 2,000lb. of nuts per acre is looked upon as a fair average crop, whilst yields of 4,000lb. per acre are not unknown. It is difficult to obtain reliable data under this head, as small areas only are cultivated in the majority of cases, and the ground nuts are grown amongst other crops.

The average yield in the United States appears to be from 1,000lb. to 2,000lb. per acre.* In Senegal, land cultivated by the natives gave from 600 to 1,800lb. to the acre, whilst land worked by the plough gave 2,700 to 6,100lb. to the acre.†

Cost of Cultivation.—The following data were kindly furnished to Mr. Lunt of St. Kitt's by Mr. W. D. Gordon of Con Phipps estate in that island, who experimented with a few acres :—

	s.	*d.*	
Close ploughing	5	0	per acre.
Hoe-harrowing (in two directions) ...	2	0	,, ,,
Planting, by hand	4	0	,, ,,
Weeding and Moulding (once) ...	3	6	,, ,,
Reaping (at 1*s.* 6*d.* per barrel) for ten barrels	15	0	,, ,,
Total ...	£1 9	6	

The yield was ten barrels per acre (weight not stated). The selling price per barrel ranges in St. Kitt's from 7*s.* to 15*s.* Taking 11*s.* as the average, the returns in this experiment were £5 10*s.* per acre, which, after deducting rent of land, cost of management, etc., would leave a considerable profit, and in addition there is the value of the vines as fodder.

* *Pea nuts, Culture and Uses*—U.S.A. Department of Agriculture, Farmers' Bulletin, No. 25, p. 16.

† *Trade of Senegal and its Dependencies* - Diplomatic and Consular Reports, No. 2,372, p. 10.

THE USES OF GROUND NUTS.

Local Uses.—As already stated the ripe seeds are parched and eaten. The parched seeds are sometimes used for the preparation of a 'cocoa.' The oil does not appear to be ever extracted.

Before proceeding to discuss how ground nuts might be utilized in the West Indies, it is advisable to review briefly the uses made of them in other parts of the world.

In Confectionery.—In the United States of America some 40,000 tons are raised annually; fully three-quarters of the total crop is used in confectionery; the better grades are roasted and eaten, and the inferior kinds made into burnt almonds, etc. *

As a Source of Oil.—The ground nut is very rich in oil,—from 30 to 50 per cent. of the weight of the shelled nut, according to published analyses. This oil is agreeable to the taste and smell, and very similar in character to olive oil and cotton seed oil. The best grades of the oil, 'cold drawn,' are employed for culinary purposes. So good is this oil that it is a common substitute for, and very difficult to distinguish from, olive oil. The lower grades of oil are used to an enormous extent in soap manufacture and for lubricating purposes. Marseilles imported, in 1900, 104,542 tons of ground nuts, principally for the manufacture of soap and of the pure oil. The bulk of these came from the British and French possessions on the West Coast of Africa, and a small proportion from India.

As an illuminant ground nut oil is of fair value, and burns a long time but does not give a very clear light.

As a Source of Oil-cake and Oil-meal.—The refuse left after the expression of the oil forms an oil-cake. Chemical analyses prove it to be extremely rich in carbohydrates and nitrogenous matters with, in addition, a considerable quantity of fat. 'It contains, as the averages of over 2,000 analyses show, about 52 per cent. of protein, 8 per cent. of fat, and 27 per cent. of carbohydrates, and is therefore one of the most concentrated feeding stuffs with which we are familiar, ranking with cotton seed meal, linseed meal, etc., and in some cases ahead of them.' †

Experiments were made in 1891–2 at the Woburn Experiment Farm, England, to test the value of ground nut cake as a feeding material for cattle. The results proved 'ground nut cake to be a useful feeding material for cattle and to have a feeding value just about equal to that of beans.' ‡

Dr. W. R. Robertson records its trial in India as a food for horses, cattle, pigs, etc. § The oil was roughly extracted from the nuts in a primitive mill of the mortar and pestle type. 'The cake broken in small pieces and steeped for 24 hours in cold water, just sufficient of which was used to make a stiffish

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* *Pea nuts, Culture and Uses,* p. 17.

† *Pea nuts, Culture and Uses,* p. 6.

‡ Dr. J. A. Voelcker, *Journal Royal Agricultural Society of England,* Series III, Vol. III, pp. 727-30.

§ Dr. W. R. Robertson, *Journal Royal Agricultural Society of England,* Series III, Vol. IV, pp. 648-57.

paste. This paste is white and has a rather agreeable nut-like smell and taste; it is readily eaten by horses. . . . . I have used the cake extensively in feeding working cattle: an allowance of 4lb. per day, with forage, kept the animals in perfect health and condition. . . . . For fattening cattle I do not know of any better food in regard alike to its feeding value and the superior quality of beef produced. As a food for cows it is admirable both in increasing the yield of milk and in improving its quality. . . . . A daily allowance of 4 to 6 lb. of the cake given in the form of paste, and mixed with 2 or 3 lb. of wheat bran, constitutes a perfect food for milch cows. I have had cows, so fed, for several years yielding well and breeding regularly. . . . . . For sheep there is no better food than earth nut cake, but for these animals I found it best to give the cake dry and broken into small pieces. . . . . Many experiments have proved the value of the cake as a food for pigs; for these animals it was generally made into a thin gruel and given mixed with bran. . . . . The same preparation, but in not quite so thin a condition constitutes a superior food for fattening poultry, though it is not so useful for laying fowls.'

As a Fodder.—The vines are largely used in some parts of the world for fodder, and under the name of 'pea nut hay' are highly esteemed in the United States.

Their value is well recognized in Barbados and after the reaping season, stacks of ground nut vines are to be seen scattered over the St. Philip's nut growing district. These stacks usually have a protective covering of guinea corn stalks, etc.

'The food value of the hay is of course higher, the greater the percentage of nuts left on the vines in harvesting. The hulls also appear to possess considerable value as a feeding stuff, being much richer in valuable food constituents (protein, fat and carbohydrates) than cotton hulls, which are extensively used in some localities in the south [of the United States] as a coarse fodder, and about equal to the poorer grades of hay. The ground hulls are used to a considerable extent as a coarse fodder in European countries.'‡

SUGGESTIONS FOR THE FUTURE.

Enough has been said to demonstrate the value of the ground nut as an article of food, as a source of oil and oil-meal and, incidentally, as fodder. It now remains to discuss how the plant might profitably be employed in the West Indies.

As a source of Food.—Ground nuts being appreciated is the West Indies for this purpose, and selling at a remunerative price, it might be supposed that enough nuts would be grown to meet the comparatively limited local demand. Such is not the case. In Trinidad, as already mentioned, the market in principally supplied with American produce. In Jamaica also

‡ *Pea nuts, Culture and Uses*, p. 6.

ground nuts are largely imported. The St. Lucia *Blue Book* for 1899 records the importation of 916 bushels of American ground nuts, valued at £155, and in 1900 of 960 bushels from the same source, valued at £172. These instances are sufficient to show that sufficient nuts for the local trade are not at present produced locally, and that there is a distinct opening for trade in this direction.

As a source of Oil and Oil-meal.—We have shown that oil from the ground nut is an excellent substitute for olive oil, and, in fact, is often unknowingly used instead of olive oil. Ground nut oil for many purposes is superior to cotton seed oil. The cake remaining after the expression of the oil is 'one of the most concentrated feeding stuffs with which we are familiar, ranking with cotton seed meal, linseed meal, etc., and in some cases ahead of them.'

What is the demand for these oils and oil-meals in the West Indies, for which the locally grown ground nut might be substituted ?

The following table shows the importations of olive oil, cotton seed oil and oil-meal and oil-cake into some of the West Indian colonies for the financial year, 1900 :—

WEST INDIAN IMPORTS OF OLIVE OIL, COTTON SEED OIL AND OIL-MEAL AND OIL-CAKE, 1900.

Colony.	Olive Oil.		Cotton Seed Oil.		Oil-meal and Oil-cake.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Gals.	£	Gals.	£	lb	£
British Guiana	†	†	97,159	8,933	327,852	930
Grenada ...	9,546	1,790	6,289*	527	270,778	824
St. Vincent ...	858	234	1,951	234	118,229	496
St. Lucia ...	8,250	1,067	36,264	3,077	108,282	500
Barbados ...	†	†	83,670	8,367	5,166,665	15,500
Leeward Islands	10,136	1,361	†	†	1,548,001	5,057
Totals ...					7,539,807	23,307

* Grenada in 1900 exported 4,115 lb cotton seed, valued at £564.

† Figures not available.

From this table we learn that in 1900 olive oil and cotton seed oil to the value of £25,596 were imported into that part of the West Indies for which figures are available. Oil-meal and oil-cake were also imported to the value of £23,307, exclusive of that imported into Trinidad and Jamaica.

With the present low price of their crop, it is not too much to say that sugar planters, at any rate, cannot afford to continue this practice. Barbados alone, as is shown, spent in a single year, close on £24,000 in cotton seed oil and oil-meal, the whole of which could be produced in the colony.

The proposed re-introduction of cotton should lead to some changes in this direction, as for every pound of cleaned cotton obtained there will be about two pounds of cotton seed. Apart from this, we have endeavoured to show that in the ground nut, a plant almost entirely neglected by planters in the West Indies, there is another source of the oils and oil-cake now imported to an unduly great extent.

AS AN ARTICLE OF EXPORT.

In order to ascertain their value in the British Market, the Department forwarded in 1902, two small consignments of ground nuts for valuation and report.

The samples sent consisted of nuts selected for size and general appearance.

Messrs. Leete, Son & Co. of Liverpool, on April 21, 1902, reported as follows :— ' Having examined the sample of ground nuts we are of opinion that same are very fine in size, and would be saleable in considerable quantities for eating purposes at a value of about £16 10*s* to £17 per ton, if the outside shell could be kept clean and bright, *(this is important, as people buying for dessert purposes require a nice appearance)* also the nuts should be *dry* when shipped, as we find that inside the shell the kernels are inclined to be mouldy in the sample.

' Should it be impossible to obtain the nuts in any better condition than the sample shows, they would only be fit for crushing purposes, and the value would only be from £10 to £11 per ton, but no doubt large quantities could be sold for this purpose.

' This year there is a partial failure in the Senegal ground nut crop, while India (East) has produced a considerably larger crop than usual.'

Messrs. James Philip & Co., to whom the second sample was sent, replied :—

' With reference to the ground nuts we shall be happy to try and sell any you may send over, but the brokers say they ought to be cleaner looking : much better specimens come from the States and elsewhere, and they will fetch about £3 to £4 a ton more *without* the shells. At present they are worth about £9 to £12 a ton here, perhaps more, but, like everything else, it is all a question of supply and demand.'

In both the reports it is to be observed that stress is laid on the importance of the nuts being clean and of good colour

One method of improving the appearance of the nuts which suggested itself was by bleaching, as is carried out with other kinds of nuts, on a commercial scale, in some parts of the world.

In the experiment made the method adopted was that described by Prof. E. W. Hilgard* as having given satisfactory results in California. The nuts were immersed in a solution made up in the proportion of 6lb. of bleaching powder and 12lb. of washing soda to 50 gallons water. After remaining in this bath for five minutes the nuts were washed under a tap, and placed in a second bath containing about 6oz. of sulphurous acid to 2 gallons of water.

The weak solution of sulphurous acid was employed in place of bisulphite of lime recommended by Prof. Hilgard, this chemical not being obtainable at Barbados. After five minutes in this bath they were again washed and then spread out in the sun to dry. The whole bleaching process (exclusive of drying) took about fifteen minutes.

The results were very satisfactory. The nuts so treated had a nice, bright, clean appearance. They were free from any objectionable smell, and their flavour was not injured in any way.

One ready method of ascertaining whether the treatment had had any injurious effect on the nuts was to test the germinating power of 'bleached' and 'unbleached' nuts from the same original sample. This was done. The percentages in the two cases were 'bleached' 74 per cent., unbleached 72 per cent.

The bleaching may safely be regarded as without harmful effect on the nuts.

THE CULTIVATION OF PINE-APPLES.

The following paper was read by Mr. Charles Eugene Smith to teachers of elementary schools, at the Mica Institution, Kingston, Jamaica. The paper first appeared in the *Jamaica Bulletin* (Vol. ix) in November 1902. As the subject of the proper cultivation, packing, etc., of pine-apples is one of general

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* E. W. Hilgard : 'The Bleaching of Nuts by Dipping.' *Partial Report of work of the Agricultural Experiment Stations of the University of California,* 1895-6 & 1896-7., p. 159.

interest in the West Indies, it has been decided to reproduce Mr. Smith's paper in the *West Indian Bulletin.* It may be mentioned that Mr. C. E. Smith is himself an extensive grower of pine-apples and his experience and knowledge of the subject are probably as good as any in these colonies:—

The pine-apple is a decidedly exacting member of the vegetable kingdom, insisting upon having its wishes and needs respected and provided for, making no allowance whatever for our good intentions, and well illustrating what Miss Greenwood calls 'the cussedness of inanimate objects.' The soil is of first and most vital importance. The pine-apple will grow upon soil too poor for other products, but this soil must be light, loose and thoroughly drained. I quote a partial analysis of a typical pine-apple soil in South Florida:—

Insoluble residue	97·5085	per cent.
Humus	·24	,,
Nitrogen	·0378	,,
Total phosphoric acid	·0336	,,
Total potash	·0086	,,
Total lime	·2100	,,

What portion of the phosphoric acid and potash given above is available is not stated.

In comparison I also give the analysis of the soils at Barbican and Billy Dun, St. Andrew, as recently furnished by the Island Chemist:—

Barbican.

Insoluble residue	77·40	per cent.
Humus	1·765	,,
Nitrogen	·1190	,,
Total phosphoric acid	·0973	,,
Available phosphoric acid	·0402	,,
Total potash	·9887	,,
Available potash	·0134	,,
Total lime	·7672	,,

Billy Dun.

Insoluble residue	80·71	per cent.
Humus	1·32	,,
Nitrogen	·0770	,,
Total phosphoric acid	·0973	,,
Available phosphoric acid	·0411	,,
Total potash	·0274	,,
Available potash	·0084	,,
Total lime	·6606	,,

The soils of Florida are so barren that the cane or banana planter of Jamaica would pass them by in contempt, yet these soils are made productive and profitable by the intelligent use of green manures and commercial fertilizers, as well as by

scientific and up-to-date methods of cultivation. Barren as they are, they give in mechanical condition just what the pine-apple desires. Stiff, hard, lumpy soils are absolutely unsuitable. If you will strip the lower leaves from a pine sucker you will note that the rootlets are already pressed close to the butt. Now if, when planted, these rootlets encounter soil, or lumps of soil, difficult to penetrate, they continue this winding instead of spreading freely through the earth, resulting in what is known as 'tangle root' and the consequent death or stunting of the plant.

I have heard the argument used that, whereas the pinguin is allied to the pine-apple, therefore any soil upon which the pinguin thrives is suitable for pine-apple growing. This is very superficial logic, however, for it is also true that the Tillandsias and Bromelias are related to the pine, yet I do not think that anyone has advocated setting pine-apple plants in the branches of the forest trees. Choose the lightest, sandiest soil you can find. Fertility is of secondary importance.

PREPARATION OF THE LAND.

Very few soils exist in Jamaica naturally light enough to give the ideal conditions desirable for the pine-apple. We must therefore prepare the land we have selected with the utmost care, being thankful that this increased expense is fully offset by the greater fertility we enjoy here. The land must be thoroughly cleared of all trees and roots and the soil well worked with plough or fork until it is as fine as the seed bed of the market gardener. Drainage is of as great importance as the soil itself, no plant being more intolerant of excessive moisture. In St. Thomas-ye-Vale I find it necessary to run ditches as close as 20 feet apart. In St. Andrew 40 feet apart will answer—the ditches being 2 feet wide and 18 inches deep. The land between the ditches is divided into beds 10 to 12 feet wide with a 1 feet path separating the beds. The land should be carefully marked out for planting, and it is well to continually bear in mind the fact that we are to engage in *intensive cultivation.*

PROPAGATION.

The pine-apple is propagated by *suckers, ratoons, slips, crowns,* and *seeds.* The word 'sucker' is used so indiscriminately in Jamaica, often referring indeed to young orange seedlings, tomato plants, etc., that I may be pardoned for defining these terms.

The true suckers are the offshoots, growing out from among the leaves of the parent plant. They are the best and, in a properly managed plantation, the only offshoots available for propagation.

Ratoons are also suckers but are designated ratoons when thrown out from underground. After the fruit is cut the ratoon is the offshoot allowed to remain to bear the following year, as it is more firmly attached to the stock than the higher suckers and has, in addition, roots of its own. When

two ratoons are thrown out one should be removed and planted.

Slips are the offshoots found at the base of the fruit in most varieties. Save that they are slower of growth, they answer as well as suckers for propagating, but, as I have remarked, in a properly managed plantation they are not available, as they should be broken off as soon as formed, so that all the strength of the plant may go into the fruit. The Smooth Cayenne has no slips, only suckers, and this is one of several reasons which accounts for the high price of this variety.

The crown is the tuft of leaves on top of the fruit. Crowns will make plants, but are of slow growth, and, save when a fruit has been spoilt by rats or sunburn, they are naturally not available for planting, the crown being an attractive feature to the purchaser.

Seeds are rarely found. I notice they are more common in Jamaica pines than in those from Florida. They are only used, after hybridizing, for the purpose of producing new varieties.

PLANTING.

The land being properly prepared and the suckers secured—by the way, they should be 12 or 18 inches long and selected from healthy plants which have borne or are bearing fruit—we are ready for planting. Opinions differ as to the best distance, there being arguments in favour of both wide and close setting. Four years ago I commenced planting at the usual Florida distance, 22 by 22 inches; then 24 by 24, 24 by 30, 3 by 3 feet, and even 3 by 4 feet. I have gradually been working back to shorter distances, and have just set 2,400 at 18 by 24 inches. I believe 2 by 2 feet may be considered safe, though much depends upon the location and variety. In St. Thomas-ye-Vale, where the sky is clouded a great part of the time and there is a heavy rainfall, wide planting seems desirable; but in St. Andrew I prefer close planting, so that the ground may become quickly shaded to prevent scalding of the roots. Care should be taken to have the plants set in true lines each way. Many methods of accomplishing this will suggest themselves. My own way is to run a base line the width of the field at right angles to the beds; I then stretch a line along each side of the bed to be planted, staking off these lines at the distance I wish to set the suckers in the long rows. I use a strip of 1 by 3 board with notches showing where each plant should be set across the bed, and move this strip from stake to stake, planting the suckers with a small hand trowel.

The handle of the trowel may be used for pressing the earth firmly about the base of the plant. The only preparation of the sucker is to strip off the lower leaves, and cut the broken end clean that it may callus readily.

CULTIVATION.

The cultivation consists in keeping the plants clean all the time. Remember that the pine-apple is an aristocrat which will

sulk if required to share its surroundings with more plebeian plants. In Florida, where the soil is practically barren of plant food, artificial manuring is necessary, and in the covered pineries about Orlando as much as 3 tons of highly concentrated fertilizers per acre are used. Again, the pine-apple shows its patrician tastes in that it is decidedly capricious as to its food. Such organic manures as cotton seed meal and castor pommace invariably give poor carrying fruit, though dried blood does not seem to be objectionable, as a test of 193 plots treated with different fertilizing ingredients and combinations of ingredients carried on by the Florida Agricultural Experiment Station resulted in favour of blood, bone and potash. It is also strange that, though superphosphates made of bone treated with sulphuric acid are not injurious, yet when the base is of rock phosphate (marine bone deposits) this is generally regarded as poisonous to the pine. I may remark, however, that I have never received any return from the money I have expended for phosphoric acid for this fruit. Up to the present time, Jamaica soils do not seem to require artificial fertilizers, while in some cases their use seems to have resulted in actual disaster. It stands to reason, however, that our soils cannot yield 10 to 20 tons of fruit year after year without this drain needing to be made good in time, and I am much interested in a series of experiments now being conducted by the Island Chemist, which may also show some effect on the carrying qualities of our fruit.

GATHERING AND PACKING.

What a sense of satisfaction the grower feels as, after months of anxiety and labour, his fruit approaches maturity and he begins to think that his woefully one-sided ledger account may begin to show a better balanced appearance! Yet beware the experience of the glass vendor in 'Arabian Nights' whose day dreams had made him Grand Vizier about to marry the Princess when a slip of the foot brought his bright visions and his fragile wares in ruin to the pavement! 'Eternal vigilance' is the price of satisfactory pine-apple sales, and all your hopes may be dashed even now by careless or improper methods. The woeful inefficiency, indifference and lack of loyalty on the part of the Jamaica labourer makes the unceasing personal attention of the employer absolutely necessary while the fruit is being gathered and packed for shipment. It is impossible for me to explain, save in the field, just when a pine is fit for picking. It varies, indeed, with the season of the year and the distance it is expected to carry. One point is vital—the fruit *must* have attained its full size. A pine not properly matured will decay before it ripens, or if it ripen it will be a poor apology in flavour for this luscious fruit. An inch or more of the stem should be left attached to the fruit which is hung up by this to dry for 24 hours or more and is then ready for packing. A number of styles of pine-apple crates are used, the important thing being that they should give good ventilation. Until recently I have used the 'Orlando Pine-apple Crate,' 12 by 20 by 22 inches, holding two layers of eight to fourteen Smooth Cayenne or sixteen to twenty Ripleys.

Later experience, however, has assured me that a single-layer crate is more desirable, as the fruit seems to carry better. The buyer also prefers it as it enables him to inspect all the fruit at a glance.

Pines should always be wrapped in something to protect them from bruising. Some use common Manila paper but this hardly gives the desired protection. I use 'Excelsior' made pine wood shavings. Clean, dry hay or straw will answer. Banana trash well dried is also used. In the Azores, corn husks, stripped fine with a rasp like a large curry comb. is the common packing material. Pines should be packed firmly that they may not fall about, but should not be jammed into the box. In packing, the first pine is placed with the butt towards the packer in the lower left hand corner of the box, the second against it, the butt at the upper side of the box, the crowns overlapping, and so on, the butts and crowns alternating. If the box contain two layers, the first pine of the second layer goes in the *upper* left hand corner, the butt coming over the crown of the fruit below it. The two layers will be just reversed as in the method of 'breaking joints,' as it is called, in orange packing. Stencil the word 'Top' on both top and bottom sides of the crate that when opened the fruit may be seen in layers just as packed. As far as possible the crowns should be protected from bruising as they add greatly to the appearance and selling value. Exercise every care to make the package neat and attractive, for with fruit as with people 'first impressions go a long way.'

INSECTS AND DISEASES.

While the pine-apple requires and repays constant attention and care, yet when compared with many other plants it cannot be said that it suffers severely from insects or disease.

The only insects which seem to affect it are—mealy bugs, red spider, and scale. The prædial thief of course comes under the head of reptiles. The red spider and scale are rarely serious. The mealy bug may become so if neglected, and will cause serious stunting of the plant and fruit. Infesting as it does the white portion of the leaves about the body of the plant the use of sprays is practically unavailing. Much good is done by dipping the base of the sucker in a decoction of tobacco stems, 1 ℔. of tobacco to 2 gallons of water, before planting, but the only sure treatment is by fumigating with hydrocyanic acid gas as recently described in a Bulletin issued by the Jamaica Botanical Department. 'An ounce of prevention is worth a pound of cure.'

The diseases or maladies of the pine are—'blight,' 'sanding,' 'spike,' and 'tangle-root.'

'Blight' is a very serious trouble generally ascribed to a fungus. An acquaintance who was visiting Jamaica last winter, and who is interested in scientific research in an amateur way, kindly devoted much time to a study of this disease, making careful microscopic studies and cultural tests which demonstrated very clearly that healthy leaves can be

inoculated through the spores of diseased plants. In practice we have reason to believe that a diseased stock will prove a centre of infection for surrounding plants. The best course to pursue is to dig up the plant and burn it immediately, saturating the soil where it stood with a strong solution of copperas. A plant, if taken up and the butt trimmed back to healthy tissues when the wilting is first discovered, may sometimes be saved, but, on the whole, I think it is wiser to be rid of it at once. Fortunately the disease does not spread rapidly and may easily be checked by the observant cultivator if taken in time.*

'Sanding' is not so common in Jamaica as in Florida, where the soil is lighter and easily blown into the heart of the plants. Ants cause much trouble here, however, by carrying earth into the leaves : but this is an effect, not a cause, and is due to the presence of the mealy bugs which the ants try to protect, being fond of the sweetish secretion with which they cover the leaves.

I am but little acquainted with 'Spike,' but have regarded it as due to careless selection or non-selection of suckers rather than as a disease. Professor Rolfs, the biologist of the Florida Agricultural Experiment Station, seems to consider it as caused by improper or ill-balanced fertilizing.

I have already referred to 'Tangle-root.' Authorities differ as to its nature, but I think that in the majority of cases it is simply due to poor preparation of the land, the roots being unable to freely enter the earth and so, winding about the butt, cause strangulation as the stock expands.

VARIETIES.

I presume that to a majority of people in northern countries a pine-apple is a pine-apple, just as to the average Jamaican a peach is a peach, yet the different varieties vary greatly in quality, appearance and merits. I think on the whole we should be thankful that propagators have not been too ambitious in rolling up a long list of names, as has been the case with oranges. The Florida Horticultural Society tabulates a list of seventy-three different varieties of oranges and that without synonyms. Counting the synonyms, which some enterprising nursery men in Florida insist upon considering distinct varieties, the list swells to something like 110. I am a rather old orange grower, but I doubt if I could identify more than fourteen of these, and to do so should have to include four of the *Citrus nobilis* class. Of course there are many others highly desirable, but I think that the average practical orange grower will make his grove of but seven or eight standard kinds.

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* According to Webber 'blight' or 'wilt' is caused by a soil-inhabiting fungus which attacks the roots. *(Yearbook, U.S. Department of Agriculture, 1895.)* [Ed. *W.I.B.*]

The same authority (and none is higher) enumerates eighteen varieties of pines as follows:—

1. Abbaka	10. Ripley Queen
2. Antigua, Black	11. Lord Carrington
3. Antigua, White	12. Prince Albert
4. Black Jamaica	13. Porto Rico
5. Black Prince	14. Pernambuco
6. Blood	15. Red Spanish
7. Crown Prince	16. Smooth Cayenne
8. Charlotte Rothschild	17. Sugar Loaf
9. Egyptian Queen	18. Enville

It is possible that some of the above may be the same under different names. On the other hand, there are some varieties not included, for example, the Trinidad of the English hot houses is not mentioned. Possibly the compilers considered it identical with the Porto Rico,—an error I think, though it may be a seedling or selection of that variety: nor does the list include a sub-variety of the Smooth Cayenne—the Variegated Smooth Cayenne bearing the same fruit but noticeable chiefly for its beautiful variegated leaves of green, white and red stripes. But one Ripley is mentioned, whereas in Jamaica we know that the Red and the Green Ripleys are very distinct. Still I mention, in this connexion, the curious fact that a Green Ripley plant often throws out a red sucker or bears a fruit having a red crown, and *vice versa*.

There are several varieties in the above list with which I am not acquainted. Probably some of these are known only in hot houses and have not been successful for open air cultivation. You are probably as familiar with the Jamaican sorts as I am; perhaps more so, as my cultivation consists mostly of Smooth Cayennes and Ripleys.

The Red Spanish, I think, is identical with our Bull-Head, though I know many will differ from me. Certain it is that I have often shipped Bull-Heads under the name of 'Jamaica Pines' and my agents in New York have reported 'your Red Spanish have sold for etc., etc.' The Black Jamaica is desirable because of its size; it is also a very fair shipper. The Sam Clark (which, of course, is not included in the list I have quoted and which, I believe, is not known outside of Jamaica) has always been an interesting native variety to me, as I believe it has considerable possibilities. It is of a good shape, packing out nicely, and has a most showy and attractive crown. To a cultivated taste its flavour is inferior and its acid distinctly 'raw.' If this can be modified by some generations of cultivation the variety will prove an acquisition. The Sugar Loaf, as largely grown in Cuba as here, is so badly affected with 'black heart' as to be of little value for shipping. While I believe there is a great field in the selection of our native pines, yet speaking from a purely commercial point of view, and considering the rapidity with which the planting of this fruit is being extended in other countries, I can but feel that the time must come in the near future when only the choicer varieties can find a market. The Porto Rico was at one time very popular for open air cultivation in Florida, especially along

the East Coast, because of its large size. I had one in Bog Walk, in this island, weighing $14\frac{3}{4}$lb. Its size, however, is its one and only merit. It is a shy bearer, requires double the room of other sorts, and in quality is no better than our Bull-Head or Black Jamaica. I do not think it is being planted largely now, better kinds having superseded it.

The Abbaka somewhat resembles a very large Red Ripley though more conical at the base. It is much above the average size of pines and is of delicious flavour—none finer for home use. In dry weather it ships very well (though this is equally true of nearly all sorts), but during the rains it is extremely uncertain. Probably no other pine is so productive of slips.

The Charlotte Rothschild is a well rounded pine of quality resembling the Smooth Cayenne, its green crown prettily fringed with fine reddish spines.

The Enville or Enville City is of medium size and excellent quality ; it is distinguished by having a mass of little crownlets instead of a single crown at the top. I have shipped so few of the Rothschild and Enville that I am unable to express an opinion as to their carrying qualities.

The Golden Queen is excellent in quality for home use ; it is a poor shipper, however, and, like the Sugar Loaf, very subject to 'black heart.'

The Egyptian Queen was at one time the favourite fancy pine in Florida. It was originally the Cleopatra, its present and better known name being evidently the result of a rather shaky knowledge of Egyptian history. It no longer holds the high place in the esteem of planters which it once occupied. It is in every way inferior to our Ripley.

The Smooth Cayenne, everything considered, is to my mind the pine *par excellence.* Its large size, perfect form, excellent flavour and beautiful appearance make it king of pines. It originated, I believe, in the English hot houses, later was grown in the Azores under glass but without heat, then carried to Florida where it is the most popular and most profitable variety grown under shelter, and is now being successfully cultivated in Jamaica. I must say I have seen specimens here equal in every way to any I have ever seen elsewhere. It is specially valuable for the English markets where size and beauty of appearance count for even more than flavour.

I should be 'carrying coals to Newcastle' to describe our famous Ripley before a Jamaica audience. Strange to say it was a failure in Florida—for what reason I do not know—and I hardly recognized it when I came here. In the qualities which please the palate I consider that it ranks above the Cayenne. Surely nothing can be finer than our St. Andrew Ripley. It is also a good shipper. I have sent it to all parts of England and had excellent reports as to its condition on arrival. I rank it with the Smooth Cayenne as the first among pines. Its one regrettable feature is its small crown. Its warmest admirers have to admit this one weak point. Could we but get the size, form and crown of the Cayenne, combined with the flavour of

the Ripley, we should have the ideal, the perfect pine, and in this connexion I must express the deep interest I feel in the experiments in crossing these two varieties now being carried on at Hope. Seeds have been obtained from this cross and the young seedlings were thriving when I last saw them. I sincerely trust that the hopes and expectations of the gentlemen who have devoted so much time and labour to this work may be amply rewarded in the results.

BAY OIL AND BAY RUM.

The preparations of Bay oil and Bay rum are West Indian industries about which there is little available information. The Bay tree of Tropical America (*Pimenta acris*) is widely distributed and there is apparently more than one variety.

The name *Pimenta* is derived from the Spanish *Pimienta*, Spanish for pepper. The name was given to the Allspice (or Jamaica pepper) when first imported into Europe.

The following is a botanical description of the Bay tree, known also as Bay berry, Wild clove and Wild cinnamon, taken from Bentley and Trimen's Medicinal Plants (1880), 110 :—

PIMENTA ACRIS, WIGHT, ILLUST. INDIAN BOT. II, P. 18 (1850).

Description.—A tree of 30-40 feet high, with ascending branches, the smaller ones subtetragonal or quite 4-angled, often laterally compressed, smooth ; bark greyish brown. Leaves opposite, without stipules, shortly stalked, 2-3½ inches long, broadly oval or obovate-oval, rather obtuse at the apex, entire, thick, smooth, strongly veined on both surfaces, shining above, paler and covered with scattered minute dots beneath. Flowers small, numerous, stalked, arranged in threes (the central one on a short pedicel, the two lateral on longer, widely spreading ones) at the extremities of the divaricate branches of large trichotomous axillary or terminal cymes longer than the leaves, the whole often forming one large corymbose inflorescence, branches slender, compressed, punctate with glands. Calyx-tube, top-shaped, fleshy, with immersed glands, lobes 5, very shallow, very broadly triangular, thick, spreading, persistent. Petals 5, roundish, spreading, white with a tinge of red, dotted with glands. Stamens indefinite, in several rows, inserted on the outer side of the epigynous disk, filaments slender, anthers short, versatile. Ovary inferior, quite fused with the fleshy calyx-tube, 2-celled, with 1-4 ovules in each cell pendulous from the top of the inner side ; style simple, tapering, longer than the stamens ;

stigma terminal, simple. Fruit an ovoid-globular berry about the size of a pea, smooth, crowned by the persistent calyx-lobes, blackish when ripe, with scanty pulp, 2-celled. Seed solitary in each cell, structure as in *P. officinalis*, but the embryo usually less convoluted.

Habitat.—This is a tree of very great beauty and elegance of growth and the polished foliage is very fragant. It grows in most of the West India Islands from Jamaica to Trinidad, and also occurs on the mainland of Venezuela at Caracas. It has been introduced into India where it is cultivated. In England it was grown first about 1750; there is a specimen in the Botanic Gardens at Edinburgh.

The genus *Amomis*, Berg, is composed of this species (which he divides into two, *A. acris* and *A. pimentoides)*, along with *A. Pimenta* and *A. oblongata*; it differs from his genus *Pimenta* chiefly in its 5 petals. *A. pimentoides* is regarded as a variety by most botanists; it has the leaves more obovate, and is the form cultivated in India.

Official Part and Names.—SPIRITUS MYRCIAE, *Spirit of Myrcia, Bay-rum*; the spirit obtained by distilling rum with the leaves of *Myrcia acris*, Swartz (U.S.P.). It is not official in the British Pharmacopœia or the Pharmacopœia of India.

General Description.—This official substance of the Pharmacopœia of the United States is imported from the West Indies. Its common name of Bay rum led formerly to the belief of its being obtained by distilling rum with the leaves of the common Bay tree *(Laurus nobilis)*; but its source was traced by Professor Maisch, as far back as the year 1861, to *Myrcia acris*, Swartz, the *Pimenta acris*, Wight, under which latter name it is described by us. Nothing definite is known about the manner in which Bay rum is distilled, and of late years the larger proportion (it is said at least three-fourths) of that used in the United States, is made at home from the so-called oil of bay, which is the volatile oil distilled from the leaves of the plant now under description. But the Bay rum as thus prepared is very inferior in fragance to that which is imported, although the quality of the latter is not equal to the specimens of former years; but it can be sold at a much lower price than the genuine substance. R. Rother states, however, that the following formula yields a product which possesses a much stronger aroma than the imported article, and is in other respects equally satisfactory:—

Take of—

Oil of Bayberry	1 fluid ounce
Jamaica Rum	1 pint
Strong Alcohol	4 pints
Water	3 pints

Mix the rum, alcohol, and water, then add the oil; mix and filter. The measures are those of the United States Pharmacopœia. Of course none of these imitations of the imported Bay rum are official.

The *oil of bay*, or as it is better termed *oil of bayberry*,

has been described by Maisch as a limpid brownish-yellow liquid, with a pungent spicy taste, and an aromatic odour like that of allspice. It is lighter than water, partially soluble in alcohol, and freely soluble in ether. Its composition has not been thoroughly ascertained, but according to R. Rother, it is a mixture of a terpene and an acid; and the same experimenter also states 'that eugenic acid, which is common to the oils of pimento and cloves, is also the chief ingredient of oil of bay, and that the difference in the odour and taste of the oils of cloves, pimento, and bayberry is determined by the characteristic terpenes.'

Medical Properties and Uses.—Bay rum is chiefly employed in the United States as a refreshing perfume in faintness, nervous headache, and other nervous affections. It may be either applied to the head, or held to the nostrils. It is also an agreeable and refreshing substance to sprinkle about the rooms of the sick and convalescent.

Bay rum is also employed by the perfumer in the preparation of hair-washes, and for other purposes.

The dried unripe fruit also forms a substitute for the official pimento or allspice.

BAY RUM.

The following information respecting the manufacture of Bay oil and Bay rum at Dominica is taken from the *Bulletin* of the Botanical Department, Jamaica (No 26) December, 1891, p. 8. Mr. Fawcett writes as follows:—

In answer to applications for information on the manufacture of Bay rum, I received several letters, the most useful of which was from Mr. H. F. Green, Curator of the Botanical Station in Dominica, paragraphs from which are given below. It was not known, until of late years, from what plant Bay rum was prepared, but it is now ascertained that the tree is *Pimenta acris*, one of the plants known in Jamaica as wild cinnamon:—

'In answer to yours of September 18, I may inform you that "Bay rum" is manufactured in Dominica from the dried leaves of *Pimenta acris*.

'Bay rum is procured by distillation, and this in a very simple manner. The leaves are picked from the trees and then dried; in this state they are placed in the retort—which is then filled with water—and the process of distillation is carried on.

'The vapour is then condensed in the usual way, and forms what is known as "Bay oil," a very small quantity of which is required for each puncheon of rum.

'The manufacture of Bay rum is carried on at the northern end of this island and proves a very lucrative business to those engaged in it, as the plants are plentiful in this district.

'The following is an estimate of rum, etc., required :—

1 puncheon rum—100 gallons about 18 to 19 proof, say at 2*s*. per gallon	£10 0 0
Empty puncheon	1 0 0
$1\frac{1}{2}$ pint bottle Bay oil pure to a puncheon of rum	16 8
	£11 16 8

'The rum must be of the strength of 18 to 19 proof or the oil will not amalgamate properly.'

In the next number of the *Bulletin* (Nos. 27 and 28) Mr. Fawcett supplements the above as follows :—

The correspondent in Dominica, Mr. H. F. Green, who sent me information about the manufacture of Bay rum published in *Bulletin* No. 26, adds a further note :—

'The dried leaves of *Pimenta acris* are shipped in large quantities from here to New York. They are generally sent away in large bales, weighing some 200 ℔. each.'

For many years the manufacture of Bay rum has been carried on at St. Thomas (Danish West Indies). This is the head-quarters of the industry. The alcohol used is white rum from the Danish island of Santa Cruz. Possibly the chief supply of genuine Bay rum and Florida water found in commerce is obtained from this island. The principal manufacturers are H. Michelsen, and A. H. Rüse. The supply of bay leaves required at St. Thomas in the manufacture of Bay rum and Florida water is obtained from St. John's (another Danish island), Dominica and the Virgin Islands.

WEST INDIAN BAY.

The following further information in regard to Bay oil and Bay rum is taken from 'Odorographia : A Natural History of Raw materials and Drugs used in the Perfume Industry,' by J. Ch. Sawer, F.L.S. (London : Gurney and Jackson, 1894) pp. 56-62 :—

Although the United States Pharmacopœia names the oil of bay 'Oleum Myrciae,' and states it to be derived from *Myrcia acris*, D.C., there is some doubt about the accuracy of the statement, the species, varieties and forms of Myrcia and Eugenia being so numerous and so nearly allied that it is probable that the leaves commercially known as 'Bay leaves' are gathered from various trees, and no attention is paid by the gatherers to the slight structural differences which distinguish botanically between the various trees. Recent opinion is in favour of these Bay leaves being derived from *Eugenia acris*, Wight and Arnott (*Pimenta acris*, Wight, Illust. Indian Bot. ii. p. 16).

Myrcia acris, D.C. (Prodr. iii., 243) figured by Hooker, is considered to be identical with *Myrtus acris*, Swartz ; *Myrtus Caryophllata*, Jacq. ; *Caryophyllus racemosus*, Miller dict ;

Myrtus acris, Colla and Plukenet. It is allied to *Eugenia Pimenta*, but differs in the flowers being always 5-cleft. It is a handsome tree, 20 to 40 feet in height, of a pyramidal form. The leaves are opposite, without stipules, short-stalked, 2 to 3 inches long, broadly oval, or obovate-oval, rather obtuse at the apex, entire, thick, smooth, strongly veined on both surfaces, shining above, paler and scattered with minute dots underneath.

The flowers are small, numerous, stalked, arranged in threes (the central one on a short pedicel, the two lateral on longer, widely spreading ones) at the extremities of the divaricate branches of large trichotomous axillary or terminal cymes longer than the leaves, the whole often forming one large corymbose inflorescence; branches slender, compressed, punctate with glands. In the woods of Antigua, Jamaica and Barbados the fragrance of the leaves of this tree fills the air. The fruit is an ovoid-globular berry, about the size of a pea, smooth, crowned with the persistent calyx-lobes, blackish when ripe, with scanty pulp, 2-celled, of aromatic smell and taste, seed solitary in each cell.

The specific gravity of the oil of 'West Indian Bay leaves' is stated by Dodge and Olcott to range between 0·895 and 1·020, and an average sample of a complete distillation to have a specific gravity of 0·965 at 60° F. Oil distilled in the New York factory of Messrs. Schimmel & Co., from imported leaves was found to have a specific gravity of 0·9828 at 15° C.; the yield being 3·5 per cent. Investigations in this respect were made by Professor Markoe, who, operating on about 7,000 ℔. of leaves imported principally from the island of St. Thomas, obtained the following results:—'The apparatus used in distilling the oil was a 200-gallon copper still, heated by steam, so arranged that either wet or dry steam could be used at pleasure. From 200 to 300 ℔. of leaves were used at each running of the still, and to work off this quantity required from eight to twelve hours, during which time from 80 to 100 gallons of distillate would be obtained. The oil comes over in two portions. First a portion lighter than water, that comes over very rapidly, and then the heavy oil, that comes over very slowly and does not easily separate from the water, with which it forms a milky emulsion. The following notes were made of one of the runs with 200 ℔. of leaves. The distillate was collected in quantities of $2\frac{1}{2}$ gallons of the oil carefully separated from each portion. The specific gravity of each portion was then taken:—

LIGHT OIL.

No. 1	0·870
„ 2	0·930
„ 3	0·946
„ 4	0·964
„ 5	0·982
„ 6	0·990

the total yield of the light oil coming over in the first 15 gallons of distillate, from which it promptly separated, leaving the water quite clear.

The distillation was then continued to obtain the heavy oil until 65 gallons more of the distillate were obtained. This oil was received in three portions and the specific gravity of each portion then taken :—

HEAVY OIL.

No. 1	...	...	...	1·023
„ 2	...	...	...	1·035
„ 3	...	...	...	1·037

The oil when first distilled is colourless, but by exposure to the air quickly acquires a yellowish tint, which deepens into a rich brown tint, and if the exposure is continued, the oil becomes quite dark in colour just as does the oil of clove or the oil of pimento. The odour of the freshly distilled oil is rank, but in the course of from three to six months, it becomes mellow and ripens into the agreeable fragrance so much liked.

Twenty pounds of the crude heavy oil, which had been exposed to the air until it had acquired a deep brown colour, were put into a 30-gallon jacketed steam still, together with 20 gallons of water. The distillation was begun very slowly, and the distillate collected in portions of $2\frac{1}{2}$ gallons. The first and second portions contained about 4 ℔. of light oil, then the water came over of a milk-white colour, and on being allowed to stand, the heavy oil subsided to the bottom of the bottles.

The distillation was very tedious, requiring twenty hours to get all the oil over. When the oil had separated from the water, the latter was returned to the still. 75 gallons of distillate were required to complete the rectification. The twenty-six portions of heavy oil were divided into thirteen portions by mixing Nos. 1 and 2 together, 3 and 4 together, and so on through the series. The specific gravity of each portion was then taken, and is given in the following table, at 85° F., the temperature of the laboratory :—

1	...	...	...	...	...	1·025
2	...	...	...	...	...	1·030
3	...	...	...	...	...	1·036
4	...	...	...	...	...	1·040
5	...	...	...	...	...	1·045
6	...	...	...	...	...	1·045
7	...	...	...	...	...	1·047
8	...	...	...	...	...	1·048
9	...	...	...	...	...	1·048
10	...	...	...	...	...	1·048
11	...	...	...	...	...	1·048
12	...	...	...	...	...	1·042
13	...	...	...	...	...	1·035

The first eight portions were nearly colourless. No. 8 had a light straw colour, 9 and 10 light brown, and 13 almost black.

Nos. 8, 9, 10 and 11 being all of the same specific gravity were mixed together and taken to represent the *pure heavy oil*

of bay. It had the following properties :—Colourless when first distilled, quickly acquiring a brown colour by exposure to the air ; the odour recalls that of clove ; the taste, hot, pungent, aromatic, very like that of oil of cloves ; it reddens the skin and produces a hot tingling sensation in the part to which it may be applied ; the effect does not, however, last long. The oil is soluble in the 95 per cent. alcohol of the market in all proportions, also in ether and petroleum benzene. It is soluble in the officinal solutions of caustic potash, forming after a short time a mass of crystals.

The specific gravity at 77° F. and at 60° F. was taken with much care using a 500-gram flask in making the determinations :—

Specific gravity of heavy oil of bay at	77° F.	...	1·052
„ „ „	60° F.	...	1·055

Ten pounds of light oil of bay, as obtained from the leaves having a specific gravity of 0·945 were then slowly re-distilled. The first portion of the distillate consisting of a clear, limpid, colourless liquid, had a specific gravity of 0·829 at 77° F. and of 0·8356 at 60° F. It was found to be perfectly soluble in strong alcohol, ether, benzene and chloroform. When the residue in the still was examined, about 4 ounces of a dark coloured, very thick body, was obtained from the sides and bottom of the still. It is carried over to some extent during the last part of the distillation.

A sample of oil distilled from leaves imported direct from St. Thomas was examined by Dr. Mittmann, in Breslau. Engenol was found to be the principal constituent ; the methyl ether of engenol was also present in small quantity, as well as pinene and probably dipentene and diterpene. The specific gravity at 15° C. was 0·970. The oil dissolved clear only in ether, petroleum ether, carbon disulphide and chloroform, while with alcohol and glacial acetic acid it gave a strong turbidity, therefore, in preparing 'Bay rum' from Bay oil, the solution may prove turbid and require to be filtered through or treated with magnesia.

In the Edition of the U.S. Pharmacopœia just published (Seventh decennial Revision) the tests for pure Bay oil have been modified in accordance with the result of the most recent investigations :—The specific gravity which formerly stood at 1·040 has been reduced to 0·975-0·990, the higher figure having been found to facilitate adulteration with oil of cloves or pimento ; the absence of these adulterants is furthermore ascertained by the following test :—

'If to three drops of the oil, contained in a small test tube, five drops of concentrated sulphuric acid be added, and, after the tube has been corked the mixture be allowed to stand for half an hour, a resinous mass will be obtained. On adding to this mass 4 c.c. of diluted alcohol, vigorously shaking the mixture and gradually heating to the boiling point, the liquid should remain nearly colourless, and should not acquire a red or purplish-red colour ; (distinction from oil of pimento and oil of cloves.)'

It is quite unusual in a work of this sort to enter into any details of retail business, such as trade formulæ of compounds, yet the following ℞. for 'Bay rum' is so strongly recommended by a leading firm of essential oil distillers that some readers may advantage by taking note of it:—

West Indian Bay oil	2 drachms.
Pimento oil	1 drachm.
Clove oil	10 drops.
Alcohol (95 per cent.)	½ gallon.
Water	½ gallon.

Mix and allow to stand for several days, then filter. Another recipe is

Bay oil	1 oz.
Alcohol, 95 per cent.	½ gallon.

Mixed and allow to stand for a fortnight; then add 1 gallon of good Jamaica rum.

Bay oil is also largely used in Germany in the preparation of Bay rum soap. This soap possesses very refreshing properties and is likely to become very popular. The same proportions of the same ingredients are used as for the wash.

DOMINICA.

The preparation of Bay oil has been carried on at Dominica for many years. Dr. H. A. Alford Nicholls, C.M.G., forwarded from Dominica to the Colonial and Indian Exhibition, 1886, an extract labelled 'Bay leaves (*Pimenta vulgaris*)'.* These leaves are used in the manufacture of Bay rum.' The Bay trees were at one time comparatively plentiful, but it is understood that, of late years, the supply of leaves has fallen off and Bay trees now exist only in the more inaccessible parts of the island. Dry Bay leaves are still being exported in small quantities. They are shipped in bales to New York and elsewhere.

In addition to the typical Bay tree (*Pimenta acris*) there exists in Dominica another tree closely allied to it locally known as *Bois Inde*. The leaves of this are also said to be used in the preparation of Bay oil. They possess a distinct odour of citronella. It is observed that in the *Index Kewensis* there is a *Pimenta citrifolia*, Kostel. (*Allg. Med. Pharm.* F.L. iv). Whether this is the same as the Dominica plant it is impossible to state. In 1883 a lemon-scented Pimenta from Dominica was observed by Dr. Morris under cultivation at Kew as *Pimenta officinalis*. On his suggestion it was propagated and distributed to Ceylon, Mauritius, and other Botanical Gardens, in the hope it might be grown to the flowering and fruiting stage and determined. Nothing seems to have resulted from this

**Pimenta vulgaris* is a synonym for *P. officinalis*, the Allspice or Pimento tree of Jamaica. As far as we are aware the leaves of the Allspice tree do not yield Bay oil.

action. It is hoped that a careful investigation will be made of the several Bay oil trees of Dominica so that those remaining may be preserved and attention given to the selection and cultivation of the best sorts.

MONTSERRAT.

At Montserrat the trees yielding Bay oil are known as wild cinnamon. There are two sorts, red cinnamon and white cinnamon. A third known as pepper cinnamon, (*Canella alba*) is probably not used for yielding oil. If it is, the oil is likely to prove of inferior quality.

Specimens of the leaves and timber of the red and white cinnamon of Montserrat were recently received by the Department from Mr. A. J. Jordan, the Agricultural Instructor. These specimens were afterwards forwarded to be placed in the museum of the Royal Gardens at Kew. As far as the leaf characters are concerned, it is probable that the white cinnamon is typical *Pimenta acris* and the red cinnamon is a variety of the latter. In neither do the leaves possess the lemon scent of the *Bois Inde* of Dominica.

Further specimens in flower and fruit are necessary before these trees can be accurately determined.

Amongst the essential oils forwarded by Mr. J. S. Hollings from Montserrat to the Colonial and Indian Exhibition of 1886 was a specimen of oil from ‘the leaves of the Bay pimento.’

The preparation of Bay oil on a moderately large scale has been taken up at Montserrat in recent years—possibly in consequence of the falling off in the supply from Dominica.

In March last Mr. J. R. Jackson, A.L.S., in notes contributed by him to the *Agricultural News* (Vol. II, p. 21) states that in the middle of November 1902 ‘two tins of distilled oil of bay, catalogued as direct from Montserrat, sold at 5*s*. 6*d*. per ℔.’ In the Blue Book of the Leeward Islands for 1900 Montserrat is credited with essential oils and essences exported to the value of £56; and 1901-02 to the value of £299. It is probable that the essential oil of limes is also included in the latter.

In Schimmel's Semi-annual Report for October-November 1902, p. 13, it is stated that ‘in consequence of the insufficient supply of good quality of leaves, genuine Bay oil has been very scarce.’

BERMUDA.

A letter was recently received from a firm of distillers of essential oils at New York stating that it had obtained an offer and samples of Bay leaves from Bermuda. Upon examination it was found that the leaves varied from the kind which was regularly used at New York for distillation of Bay oil. This, it was stated, was usually received from Dominica.

There are no species of Pimenta native of Bermuda. The only myrtaceous plant found there, besides the guava and pomegranate, is the shrub known under the local name of

'Stopper' *(Eugenia monticola).* It is very unlikely this would yield Bay oil.

PROTECTION AND CULTIVATION OF BAY TREES.

In view of the limited distribution of Bay trees (at least in sufficient quantities to support an industry), it is desirable than an inquiry be made as to the quantity of trees still remaining, especially at Dominica, Montserrat and the Virgin Islands. Such trees might be protected, if on Government lands, and steps taken to extend them into areas where they formerly grew but have since been destroyed. The leaves of the Bay tree may be regarded as the most valuable product of the fast disappearing West Indian forests. It would be a matter of regret if the supply, already much reduced, were to fail entirely.

Where the trees exist on private lands the owners might regulate the collection of the leaves and prevent permanent injury to the trees. This would be quite possible if the small terminal branches only were broken off as in the case of the Jamaica pimento. Further, in regard to extending the area covered by the trees: the Bay tree is so closely allied to the Pimento tree it is probable that the same simple system of cultivation would equally suit it. The berries of the Pimento tree, when ripe, are greedily eaten by birds and the seeds dropped everywhere in the neighbourhood. These readily give rise to seedlings that require only to be thinned out and kept free of other growth to develop within a few years into large trees.

Where Bay trees do not already exist it would be necessary to obtain seedlings and care for them until they are established. Afterwards they would spread rapidly in the district. Underneath Bay trees, as in the case of Pimento trees, sheep and cattle might be grazed and thus large areas could be kept productive at a small cost. We commend the subject of cultivating Bay oil trees to the consideration of landowners in Dominica, Montserrat and the Virgin Islands, where native trees already exist, and to others who possess grass land suitable for a modified system of orchard cultivation with useful and hardy trees.

CHEMICAL SELECTION OF THE SUGAR-CANE.

The subject of the possibility of improving the sugar-cane by selecting canes in the field remarkable for size, prolificness, early maturity and high saccharine quality, and of producing from these selected canes, by tops or cuttings, a succession of canes possessing similar or improved qualities was discussed in

the *Kew Bulletin* (1894, pp. 86-96 : 1897, pp. 317-318, and 1899, pp. 45-46).

A further contribution on the same subject appeared in a paper by Professor d'Albuquerque, in the *West Indian Bulletin* (Vol. I, p. 185).

The following is a brief extract from this paper :—

'Looking at the matter from a theoretical standpoint, one cannot help thinking that canes produced from the buds of a parent cane, are likely even if grown under precisely similar conditions (if it were possible to do so) to manifest slight differences in their various properties, such as the length of their joints, the amounts of sugar and other substances in their cells, the germinative power of their buds and so on. One would expect that the canes so produced from buds, while exhibiting no striking variation from the parent, would oscillate as it were in their properties about the mean formed by the parent plant, and that by selecting the canes richest in one of those properties (say sugar production), the canes produced from the buds of the daughter canes, would oscillate in their properties about a new mean (that of their mother canes) and a mean slightly higher than that of what I may call the grandmother cane. And one would expect that by a repetition of this process of selecting the richest from which to propagate, the average richness of the variety would be increased. Admitting that it is possible for the sugar-cane to contain more sugar than it does now, it does not, in order to test the theoretical possibility of this enrichment, seem necessary to me to show, as suggested, those striking variations known as bud variation : the essence of the idea lies in a gradual integration of small differences, and not in a change *per saltum*.'

We are aware of the difficulties that surround an investigation of this kind and also that there are one or two scientific men who have already expressed an opinion adverse to the success of such an investigation. On the other hand, there are equally experienced and competent men who are not prepared to abandon the idea until it has been more fully worked out.

With the view of placing the facts on record and leaving them for the present to speak for themselves, we quote the following from an Appendix to the Report on the 'Sugar-cane Experiments in the Leeward Islands for the season 1900-1901' by Mr. Francis Watts, B.Sc., F.I.C., F.C.S., (Part I, pp. 31-32):—

From time to time the idea has been put forward that material improvement may be effected in the sugar-cane by selecting, for planting, cuttings from the richest canes. Edson, Kobus, and Bovell have worked in this field, their work being conveniently summarised in the *Kew Bulletin*, already referred to.

In these investigations a difficulty at once arises in determining which is the richest cane, for a sugar-cane before flowering is in a condition of continuous growth, so that its upper joints are unripe while the lower ones are of varying degrees of ripeness. The composition of the juice from such

a cane will therefore vary in character in the proportion which the unripe joints bear to the ripe ones. Similarly, every cane in a bunch varies from its neighbours.

It was thought that this difficulty might be largely overcome if the canes were judged on the character of the juice obtained from the basal joints only, and that the juice thus obtained might be held to indicate, more closely than the juice from the whole cane, the character of the whole cane when ripe, and that in this way a better selection of rich and poor canes might be made. This method is practically that followed by Bovell, but he does not appear to have proceeded on any systematic lines as regards the manner of cutting, that is, he did not cut his canes at any fixed point in relation to the base, nor does he explain if short canes were excluded.

Accordingly on March 9, 1900, 200 canes of the White Transparent variety were taken; each cane was of such a length that it had not less than ten joints; the basal portion of the cane was cut off in the middle of the fifth internode, this portion was crushed in the Chatanooga mill and the juice polarized. The tops were then cut from the ten canes which afforded the richest juice. Similarly the tops were taken from the ten canes which afforded the poorest juice. From each cane three plants were obtained, thus giving 30 'high' and 30 'low' canes.

The following table gives the amount of sugar, in pounds per gallon, of the juice of the selected canes:—

'High' canes planted.	'Low' canes planted.
2·375	1·496
2·336	1·581
2·319	1·634
2·314	1·647
2·298	1·716
2·274	1·746
2·272	1·754
2·266	1·775
2·258	1·809
2·245	1·831
Mean 2·296	Mean 1·699

By conducting two series of experiments, one directed towards securing a richer, and the other a poorer cane, the results of the selection will be made more evident by the divergence of one series from the other if the method produces any results.

On February 28, 1901, the canes thus grown were reaped, 200 canes of the requisite length being taken from each plot and examined as in the previous case. From the 'high' plot the ten canes yielding the richest juice were selected and employed for planting another 'high' series. Similarly from the 'low' plot the ten canes yielding the poorest juice were taken for planting another 'low' series. These will be repeated in 1902.

The following table gives the amount of cane sugar, in pounds per gallon, of the juice of the selected canes :—

'High' canes planted.	'Low' canes planted.
2·181	1·522
2·152	1·554
2·131	1·573
2·123	1·576
2·110	1·581
2·102	1·598
2·091	1·599
2·091	1·599
2·072	1·629
2·072	1·637
Mean 2·113	Mean 1·587

The canes thus selected for the second trial diverge somewhat more widely than those employed in the first.

The arithmetical means of the results obtained upon polarizing the juice of the 400 canes are as follows :—

Mean of 200 'high' canes ... 1,925℔. sucrose per gallon.
Mean of 200 'low' canes ... 1,905℔. " " "

Difference ... ·020℔. " " "

Thus showing a gain of 1 per cent. in favour of the 'high'

canes; this is so small an amount that it may lie entirely within the limits of experimental error.

These experiments are placed upon record without any attempt to draw conclusions from them at so early a stage; it is evident that many years must elapse before definite conclusions can be drawn. Efforts will be made to continue these experiments for several years.'

In the following year in an Appendix to the Report on the 'Sugar-cane Experiments in the Leeward Islands for the season 1901-1902.' by Mr. Francis Watts, B.Sc., F.I.C., F.C.S. (Part I, pp. 52-55), there is further information on chemical selection of the sugar-cane as follows:—

The work in connexion with the experiments reported upon in the Appendix of last season's report has been continued on the lines therein laid down.

It will be remembered that these experiments consist in selecting (*a*) a series of canes rich in sucrose, called 'high' canes, and (*b*) a series of canes poor in sucrose, called 'low' canes, and planting cuttings from the canes thus selected.

The following year the ten richest canes are selected from the rich or 'high' plot, and the ten poorest canes from the poor or 'low' plot, and these are again planted.

The object of the experiments is to ascertain whether the saccharine content of the sugar-cane can be affected by selection of cuttings.

The canes are examined by cutting off the basal portion in the middle of the fifth internode from the base, crushing this basal portion in the Chatanooga mill, and determining the amount of sugar in the sample of juice so obtained by means of the polariscope. No cane is examined which has less than ten joints. All the comparisons and all the analyses mentioned in this Appendix are based upon samples obtained in this manner.

The average sugar content of the juice of the canes selected for planting in the first experiment was:—

'High' canes ....2·296 ℔ sucrose per gallon
'Low' canes ....1·699 ℔ sucrose per gallon

From these there was grown a crop of canes which upon examination in the manner described gave juice having the following sugar content:—

'High' canes ....1·925 ℔ sucrose per gallon
'Low' canes ....1·905 ℔ sucrose per gallon

200 canes from each plot being separately examined; from these ten canes were selected from each group and each cane afforded three cuttings; the canes grown from these cuttings are now reported upon. In this year's experiments a record has been

kept of the character of the juice obtained from each of the twenty canes: a comparison of the juice obtained from the parent canes and from the progeny is given in the two following tables:—

'HIGH' CANES.

Cane sugar per gallon of juice expressed from basal portion of canes.		Difference.
Cane used for planting.	Canes reaped.	
1901.	1902.	
2·181	1·934	– ·247
2·152	2·115	– ·037
2·131	1·799	– ·332
2·123	2·179	+ ·056
2·110	2·054	– ·056
2·102	1·552	– ·650
2·091	1·910	– ·181
2·091	1·900	– ·191
2·072	2·155	+ ·083
2·072	2·242	+ ·170

‘LOW’ CANES.

Cane sugar per gallon of juice expressed from basal portion of cane.		Difference.
Cane used for planting.	Canes reaped.	
1901.	1902.	
1·522	1·637	+ ·135
1·554	1·780	+ ·226
1·573	1·947	+ ·374
1·576	1·759	+ ·183
1·581	1·921	+ ·340
1·598	1·998	+ ·400
1·599	1·886	+ ·287
1·599	1·839	+ ·240
1·637	1·567	− ·070

The arithmetical means of the results obtained upon polarizing the juice from all the canes from the ‘high’ plot and all the canes from the ‘low’ plot are as follows :—

Mean of 163 ‘high’ canes	2·011 lb.	sucrose per gallon
Mean of 153 ‘low’ canes	1·793 lb.	,, ,, ,,
Difference	·218 lb.	,, ,, ,,

The gain this season is therefore over 10 per cent. in favour of the ‘high’ canes.

There was considerable variation amongst the individual canes; advantage was taken of this to select the ten richest from the high canes, and the ten poorest from the low canes for the purpose of starting two new plots. The following table

gives the sugar content of the juice of the selected canes, which are now planted to produce canes for comparison in 1903 :—

'High' canes planted.	'Low' canes planted.
2·348	1·010
2·330	1·121
2·314	1·259
2·314	1·265
2·277	1·350
2·269	1·382
2·269	1·384
2·266	1·408
2·266	1·430
2·258	1·443
Mean 2·291	Mean 1·305

Difference ·986 ℔. per gallon.

The difference between the high and low canes used for planting for the season 1902-3 is much greater than it has been upon the two previous occasions when the differences were ·597 ℔. and ·526 ℔. sucrose per gallon.

The results of this year's experiments appear to indicate that the canes are influenced by the selection, as there is a difference of over ten per cent. between the sugar content of the high and the low canes. Whether similar differences will be maintained in future experiments it is impossible to say. Knowing the danger of generalizing from insufficient data, it is deemed desirable to place the facts upon record and to continue the experiments, without, at this stage, endeavouring to draw conclusions from them.

In comparing the juice of the canes used for planting with the juice afforded by the canes raised from them, it will be seen that in the case of both the 'high' and the 'low' series there is a tendency to return to the mean or normal: most of the 'high' canes planted afforded progeny yielding on the average poorer juice than the parent canes, whilst most of the 'low' canes planted produced canes yielding on the average juice richer than the parent canes: but on the whole, this year,

the normal or mean was not reached, as the difference between the average of all the canes of the two groups (·218 lb. sucrose per gallon) clearly shows.

BIRDS OF BARBADOS.

In the *West Indian Bulletin* (Vol. III, pp. 333-52) there was reprinted an interesting paper on the 'Birds of Barbados' originally contributed to *The Ibis* by Colonel H. W. Feilden, C.B., in 1889.

In the present article it is proposed to publish further information on the same subject in the hope that, in this thickly populated island, landowners and agriculturists generally will be moved to do all they can to protect the birds, not merely in return for the services rendered by them as weed-seed and insect destroyers, but in recognition of the pleasure and enjoyment to be derived from observation of the habits and behaviour of birds. We should feel a great deal poorer and the island would lose much of its attractiveness if birds were allowed to disappear from our fields and gardens.

Latterly the Imperial Department of Agriculture has taken steps to ascertain the exact position in regard to the destruction of birds said to be going on in this island. In this inquiry it was not intended to enter into the question of the shooting of the migratory birds such as plover, snipe, curlew, pika, cue, chirp and yellow-legs, that annually visit the island in their autumn flight to South America. The shooting of such transient visitors may be regarded as legitimate sport not likely in any way to diminish the number and usefulness of the resident birds. It is these latter, numbering at present only about fifteen species, that are sought to be protected in the interests of agriculture.

The following extracts are taken from letters recently received by the Department from leading members of the community, who are in a position to afford reliable information respecting the destruction of bird life going on in the island :—

Mr. Robert Arthur, Snr., (Tweedside) writes :—

'I can assure you that the destruction of the wood dove and ground dove is very great by means of traps and springes.

'For years I have frequently found traps and springes set in my grounds, in consequence of which nearly all the wood doves which used to build their nests in my trees have been destroyed. It seems to be impossible to detect the culprits, although I have constantly offered rewards for their capture.'

Mr. J. P. Massiah (Valerie) writes :—

'There are no professional bird catchers here who follow that work as an employment. Prowling boys may catch a few wood doves and ground doves in springes for sale as cage birds, but these are not many. Most of the dove kind congregate round the town and are to a great extent fed and protected by the residents.

'To encourage the planting of trees about the island, and the individual efforts of the resident gentry, are the best means for protecting the birds that I can suggest.'

Mr. J. R. Bovell, F.L.S., F.C.S. (Botanic Station) writes :—

'From personal knowledge and from information obtained from various sources, I am satisfied that a considerable number of both the wood and ground dove are caught by the peasant boys with springes and traps for the purpose of eating them. Some years ago sportsmen would walk along the grass lands bordering on the coast in St. Philip shooting the ground doves for practice, and for so-called "sport"; but I have not heard or known of this being done lately.

'With regard to blackbirds being shot, I do not think this is often done, as the planters recognize now that, although the blackbirds do a little harm by pulling up the young corn, they do a great deal of good by destroying insects, and so do not allow them to be killed. The peasants rarely catch them as they do not consider the blackbird good to eat.

'Now, as to the best means of putting a stop to the destruction of these birds. At the present time I hardly think it would be possible to get the Legislature to pass an Act to prohibit the shooting or snaring of any birds; but I think, however, that a great deal might be done by a circular letter tc every planter in the island, pointing out the help these birds are to the agriculturist as weed-seed and insect destroyers and asking them in their own interest to use their influence in preventing the destruction of, not only doves and blackbirds, but any other birds that are known to be helpful to the agriculturist.

'As you are aware, blackbirds destroy a large number of caterpillars that attack the sweet potato vine: they also destroy the injurious "lady-bird beetles," and the doves destroy weed-seed, etc. These facts, if forcibly put before the planters, would, I believe, do much to prevent the destruction of their feathered friends.'

Mr. A. A. Evelyn (Spencer's) writes :—

'I do not think any are destroyed by regular sportsmen. A few are shot by young men from Bridgetown who get a day's shooting on the swamps and pastures on the bank holidays which occur during the shooting season in August and October, and I have been led to believe the wood dove is trapped by boys in the suburbs of Bridgetown; but it is a very rare thing now to see anyone in the country districts of the island shooting or catching our birds by means of springes or traps.

Hundreds of blackbirds and sparrows got destroyed in the hurricane of 1898, but these are again increasing, while the wood dove is, I am sure, more plentiful about the island than it has ever been.

'The little ground dove has considerably decreased in numbers within the last few years. Its habit of building its nest in the holes of the cliffs and its fondness for the Balearic berries which abound on the rocky lands of the coast make it an easy prey of the mungoose which lives among these rocks and bushes. Putting a price on the head of this animal would, I am certain, stop the destruction of this pretty and harmless little bird.

'The grass canary* which builds its nest in the sour-grass fields is in this district increasing rapidly, and is often seen in large flocks of from fifty to a hundred.

'It may interest you to know that several swallows were flying around here last week (March 13, 1903). I have never seen them so late before. You may also like to know that a pair of Two-penny Chicks are at present to be seen around the edges of a pond on Clapham estate in St. Michael.'

The Hon'ble F. M. Alleyne, M.L.C., (Porter's) writes :—

'When we first began to reside here, some six years ago, we frequently found snares and traps set, chiefly for ground doves and wood doves, in the woods and pastures round this house. These, when found, I invariably had destroyed and the setter punished when detected. The watchman was also liable to punishment if he allowed any to pass by unnoticed. For the last three years I do not think I have seen any.

'The diminution of birds of all kinds after the hurricane of 1898 was pitiful to see, but this year they seem to have been quite restored to their former numbers, and blackbirds, wood doves, ground doves, banana birds, sparrows and humming birds are in as great abundance as I have ever seen them.'

Mr. J. J. Law (Ambleside) writes :—

'I have read with great interest Colonel H. W. Feilden's account of the birds of this island in the *West Indian Bulletin* and I have to thank you for sending it to me.

'I am sure the wood dove is constantly taken by means of traps. I am told that they are sold, by the boys who catch them, as cage birds. I have on several occasions destroyed these traps set in my grounds. I am sorry to say that I only see two wood doves about here now. Some months ago they were quite numerous in comparison. I understand that a good many are to be seen in the grounds and trees of St. Michael Deanery, but that the boys are constantly after them.

'The small ground dove, once so plentiful in the island,

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* The Barbados 'grass canary' has been identified at the British Museum (Natural History) as *Sycalis luteiventris*. It is not found in any of the other West India Islands, and is probably an introduction from the mainland of South America (see *Agricultural News*, Vol ii. p. 135).

has been greatly reduced in number since the advent of the mungoose, and I believe also that they are shot to be eaten. I saw a good number of them on Bromefield pasture, St. Lucy, not long ago; but on the Fortescue Savannah, where they used to be in numbers, I only saw one, on my way from St. Andrew's last week.

'I do not think that the blackbird is destroyed; indeed his value is pretty well established in public opinion and, generally, he is protected.

'With regard to the best means of protection. I think we want to get people, generally, to take an interest in our birds, and if the public press would help, from time to time, by drawing public attention to the question in the same way that you do in your valuable papers, a great deal of good could be done.'

Mr. George E. Clarke (Græme Hall) writes:—

'I am of opinion that considerable destruction is going on in this island with the wood dove, as it seems to me to be caught or trapped on every possible occasion by boys to whom it means a good deal, or the money derived from the sale of it, to buy food with. On an estate I recently took charge of, I found traps set regularly on the pastures for these birds, and many years ago I knew boys who explored the gullies in St. Peter's parish and were experts in finding the nests, and used to take the birds out just before they could fly. The ground dove is sometimes shot on the pastures—principally on bank holidays—but not so much as formerly.'*

The Rev. N. B. Watson (St. Martin's Vicarage, St. Philip) writes:—

'In reply to your letter of March 20, respecting the destruction of native birds by means of traps and springes, I beg to say that, as a result of much inquiry and personal observation, I am convinced that snaring is the means whereby a large number of birds are destroyed.

'In this district the snaring season begins in March, and ends towards the close of June. The only birds for which traps are set are the ground dove and the wood dove. The latter nests during March and April.'

Dr. C. J. Manning (Rosemont) writes:—

'With regard to the destruction of birds, I am quite certain some species are steadily decreasing—the wood dove is suffering terribly, every stable boy or gardener sets springes for them and catches them to eat. Unfortunately they are very easily caught. Not long since I counted 47 in one cage for shipment to England; I was told afterwards that, as the weather was cold on the voyage, only nine reached their destination.

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* Mr. Clarke has since stated that, in one instance reported to him, the skeletons of doves had been found in springes that had been set and afterwards abandoned. The birds in this instance had been caught and had been allowed to die in the traps.

They were going over to some gentleman who makes "doves" his special study: he afterwards wrote to the man who sent them to him and said he had succeeded to get them to breed. This was strange as they rarely breed in confinement even with us—occasionally they can be induced to cross with our ring dove (Barbary dove) and the result is a mule bird of exquisite beauty, with most plaintive and melodious note. The wood dove ought most certainly to be preserved by an Act of the Legislature.

'Our little ground dove is also being rapidly exterminated by the mungoose; they catch them whilst feeding on the ground and also rob their nests in the cliffs and ledges of the rocks where these little doves love to build.

'The blackbird does not suffer much, I think. He is a knowing little customer that generally manages to take care of himself. Curiously enough he will not live in confinement, and having an exceedingly strong and disagreeable odour, like starlings and birds of that class, nobody cares to keep him. The sparrow is the only bird I think of no use to us; he is a terrible destroyer of fruit, tomatos, etc., and I have studied him all my life and, fond as I am of birds, have never yet discovered that he is of the slighest use to us. I hope you will be more successful than I have been in persuading the House of Assembly to pass an Act to preserve our birds. I am willing to do anything in my power to advance such a desirable scheme. I have been working at the birds migratory, as well as those with us, for the last twenty years and am now engaged in making water-colour, life-sized drawings of them, but it is a very difficult matter to collect all the information necessary. One of my chief difficulties is to establish the radius which limits the existence of our birds, and unless one had time to make a round of these islands or could get the necessary information from reliable sources, any work on the birds of Barbados must necessarily be very incomplete.

'With regard to the migrants it is pretty easy sailing, as they have been traced more or less accurately over very considerable areas of the world's surface; but with our local birds, I am pretty certain that some of our supposed constant residents are occasional migrants.'

The following information, presented in the form of question and answer, describing the methods adopted for catching wood and ground doves at Barbados was gleaned from a number of boys in a country district. It was communicated by a correspondent who vouches for the genuineness of the replies given in each case. What is herein stated may be accepted as typical of what is going on, generally, in this island:—

Best time of year for snaring birds?

March to June.

Why?

Bird food is scarce, and as the doves are busy making their nests in March they have not the time to search for food.

In April and May they want more food, as they have to provide for their young ones.

Kind of birds for which traps are set?

Ground doves. Wood doves.

What becomes of the captured birds?

The wood doves are sold. Ground doves are roasted and eaten; some are caged.

Are birds, other than doves, ever captured?

Yes, but very seldom.

What birds?

The sparrow chiefly. Blackbirds occasionally.

Name the different traps employed for snaring birds, and how are they made?

(*a*) The springe:—This is set for 'little doves'; it is made of a bent twig and meshed with twine to which 'noosed' horse-hair is fastened.

(*b*) The down-fall or basket trap:—Made of twigs fastened together in the shape of a roof and set by means of a trap, which, when touched by the bird, causes it to fall and encage it. This is set for the wood dove.

How many springes are worked by one boy?

The majority replied one; some, however, possessed as many as three.

Number of doves caught by one springe during a day?

One.

Why have most boys only one springe?

Can't get horse-hair to set more.

(*a*) When do ground doves build their nests, and (*b*) where do they build them?

(*a*) During the month of March. (*b*) On the ground, at the edge of a marl hole; on the sea cliffs: in low growing bushes and in manchineel trees.

(*a*) Description and number of eggs laid by the latter dove. (*b*) Description of nest.

(*a*) Eggs, two in number, white. (*b*) Nest similar to that of domesticated fowl; made of grass roots and other coarse material; not roofed.

(*a*) How do you bait the traps? (*b*) What is the best bait?

(*a*) Guinea corn is placed in the trap, and a few grains scattered around it to lead the birds up. (*b*) Guinea corn is the best bait; but, if water is scarce, the bottom of a bottle is buried in the ground, filled with water, and the springe is placed over it: this is a better bait than Guinea corn.

The points brought out in these extracts are (1) that there is no check on the destruction of birds in this island; (2) that wood doves and ground doves are being regularly trapped both in the breeding season and out of it and, at present, it is perfectly legal to do so; (3) that between the action of the mungoose and of men and boys, the native doves and some other birds will, sooner or later, disappear from the fauna of this island.

The following extract is taken from an article that appeared in the Barbados *Weekly Recorder* of March 21 last. This serves as a useful summary of the information in the preceding paragraphs, and the hope therein expressed, that the Legislature will be moved to take action for the protection and encouragement of bird life in the island, has our heartiest support :—

'For many years it has been noticed that the birds of Barbados are rather on the decrease than the increase, and, indeed, it is said by some old livers that several species have disappeared altogether. We cannot exactly say what causes have led to the disappearance of any of our bird species, but we firmly believe that destruction and molestation, influenced by false apprehensions, have had a lot to do with the decrease in the numbers. Six or eight years ago insect pests were numerous among the crops of the island, some of them doing incalculable damage thereto. Just then the attention of the community was directed to the usefulness of birds in keeping under insect pests, and the protection of our birds was advocated in articles written in the press by a stranger who was at the time living amongst us. Protective legislation was strongly recommended as the proper remedy for restoring the balance of nature, and a Bill was brought before the House of Assembly having for its object the protection of the birds of the colony. That measure was debated at considerable length, but so diversified were the opinions entertained by hon. members that, after it had been considered in committee, it was thrown out by a small majority vote. Whatever motives may have influenced the majority of the House to throw out the Bill, we do not think it can be said that, since then, the birds of this country have been made to suffer greater molestation than they had to endure in former years. At the same time we regret that there is not already on the statute-book a law protecting birds and making their destruction a punishable offence. It is our hope that the raising of this question again will have the wholesome effect of creating increased sympathy for our birds, many of which are pretty willing to be on friendly terms with us in our homes, if we would but reciprocate their familiarity; and that, during the next session of the Legislature, a law will be passed for their protection and encouragement as a mark of the increased intelligence of the community.'

As an instance of the amount of pleasure and enjoyment that may be derived from daily observations of the habits and behaviour of birds, we reproduce below a brightly written sketch contributed some time ago to the *Pilot* by the Revd.

Canon Bindley, D.D., the Principal of Codrington College. The writer evidently possesses the true instincts of a lover of birds, with the additional gift of being able to write about them and their ways, true to life, and in an attractive and sympathetic manner :—

'The number of resident wild birds found in Barbados is not large, yet the observant bird-lover may derive a good deal of amusement from studying the habits of some of the most familiar species. "How tame your sparrows are!" is the first exclamation of a stranger to Barbados, as he sits down to breakfast. You explain that it is not tameness, but impudence, and point to the fruit on the sideboard, carefully covered to prevent the ravages of importunate beaks. The sparrow (*Loxigilla barbadensis*), indeed, makes himself as much at home in the house as out of it, nor is he in the least scared by your presence, being as genial and confiding as an English robin. One reason for this fearlessness, which is common to nearly all West Indian birds, is not far to seek. The negro boy never robs the birds' nests: they do not interest him; his bump of mischief is not developed, nor is he yet sufficiently advanced in civilization to love destruction of life for its own sake. Consequently all kinds of small birds—sparrows, yellow-birds, yellow-breasts and humming-birds, build their nests in shrubs which line a frequented road, or in the plants in a fernery, without the least attempt at concealment of their domicile. I have had a sparrow perched atop of a book as I held it in my hand reading, who, after liberally helping himself to toast and bananas, appeared to desire now to gratify an intellectual appetite hitherto unsuspected. One morning the same greedy creature actually fell into the milk jug having over-balanced himself in his endeavour to reach the milk, and was rescued half drowned. Did the accident daunt him? Not a bit. Taking a half-circle flight outside, he re-entered the window and, with feathers still milky, began another raid upon the buttered toast. Sometimes, however, this excessive domesticity is destructive of more valuable things than small eatables. I remember when a large table had just been set for dinner, seeing a sparrow fly into the room and alight upon the edge of a champagne glass. This he at once upset by his weight, and it fell to the floor with a crash. He then coolly hopped to the next glass, with the same result, and would have probably gone the round of the table had he not been at once detected and banished the room. This undoubted element of chance destruction of wine-glasses has to be taken into account by every householder, but it is a grand loophole of escape for careless servants, when they have perhaps twisted your best glasses off their stems in heedless washing, to be able to debit the sparrow with the mischief. Worse still, a sparrow has been known actually to ruin a wedding-cake during the absence of the bride at church, chipping the icing with his beak and rolling the sugar presentment of Cupid on the floor.

'A more comical but less confiding bird than the sparrow is the so-called blackbird (*Quiscalus fortirostris*). It is, indeed, well named, for it is black all over from beak to toe, but in appearance it resembles the English starling more

than the blackbird. Of its various antics, quaint convulsions, and strangely curious notes it is impossible to convey an adequate notion on paper. They must be seen and heard to be thoroughly enjoyed. Indeed, it sometimes seems as if their grotesque actions were performed solely with a view to the amusement of the onlooker. Their sleek, attenuated figures, dapper and dainty, sometimes convince one that they must be encased in diminutive stays, when suddenly, for no apparent reason, the feathers will all be erected, the tail spread out heavenwards, the head poked forward, and some notes will be ejaculated which are capable of various interpretations. To the negro on Saturdays the bird appears to say, "Have you got your pay?" To myself when sowing vegetable seeds in the garden, the phrase becomes "Is it worth your while?" conscious as I am of the fact that, as soon as my back is turned, the irritating creature will investigate the rows with his inquisitive beak. To the West Indian generally, who is not guilty of precipitancy of action in a climate "where it is always afternoon," the bird utters the reassuring statement. "We shan't be long!" This ambitious attempt at syllabic utterance is varied by a rough harsh "cluck" which is generally, I believe, a note of warning; and to hear it rapidly repeated by a flock of fifty or sixty birds, should a cat suddenly appear round a corner, is for all the world like listening to the winding apparatus of a large clock. . . .

'Opposite my house is a small lake stocked with golden carp and crayfish. Here in the early morning or late afternoon may be seen an expert fisherman of the heron family known locally as a gaulding (*Ardea virescens*). The gaulding will sit on a bough that overhangs the water, or, still as a statue on the edge of the lake, craning his neck forward and watching the dark depths with his piercing eyes. Suddenly he will dart down, transfix an unwary fish with his long beak, and quickly consign the whole to the region set apart for gastronomic purposes. Another time he will conceal himself on a fallen palm-leaf floating on the water, and, blown hither and thither on this chance raft, will seize fish after fish that never suspected his presence on the bit of every-day flotsam. Space will not permit me to tell of the humming-birds or "sun-birds" that build in a plumbago bush under the drawing-room window, or of the "parson-bird" (*Euethia bicolor*), with his black hood and his wife dressed in dusky grey, or of the "sugar-bird" (*Certhiola barbadensis*), with his dainty yellow stomacher, who will leave his favourite tree-top and take a morning repast of finely ground sugar from the window-sill, and then indulge in a bath in the finger-basin on the breakfast table. Let it suffice for me to assure all true bird-lovers that the characteristics of bird-life in the islands of the West are not less interesting than in those other countries which have been obliged to resort to "Wild Birds' Protection" Acts.'

THE CULTURE AND USES OF THE SPECIES OF EUCALYPTUS.

The following account of the culture and uses of the Eucalypts appeared in a Bulletin (No. 35) by Mr. A. J. McClatchie, M.A., recently published by the Bureau of Forestry of the United States Department of Agriculture. The Imperial Department of Agriculture has constantly advocated the planting of trees to replace those cut down for fuel, etc., and among the trees that might be used for this purpose, probably none would be more valuable than some of the species of Eucalytus.

The Bulletin is entitled 'Eucalypts Cultivated in the United States' and, besides the part reprinted below, contains a large number of splendid plates and a short account of every species of Eucalyptus which has been introduced into the United States and which it has been found possible to identify.

The native home of the Eucalypts is Australia and some of the adjacent islands, including Tasmania, New Guinea, Timor and one of the Moluccas. All but a very small percentage of the species are found on the continent of Australia itself. A small number grow both in Tasmania and in Australia, one of these being the 'Blue Gum,' *Eucalyptus globulus*, the species that has been cultivated most widely throughout other parts of the world.

The Eucalypts constitute a considerable part of the forests of Australia, and are said to give a characteristic appearance to the landscape of the regions in which they grow. They are known in their native home as 'Gum trees,' 'Mahogany trees,' 'Box trees,' 'Stringy barks,' and by quite a number of other names, the first being the most common appellation. Notwithstanding the general use of the term 'Gum tree,' the name is not an entirely appropriate one, as the exudations from the trees are in most cases not gums, but resins. The name 'Eucalypts,' proposed by Baron Von Mueller, and used in this publication, is more suitable and euphonious. The only Australian common names that have been generally adopted in America are 'Blue Gum tree' for *E. globulus* and 'Red Gum tree' for *E.rostrata* and several other species, indiscriminately. In Australia several species are known as Blue Gums and several as Red Gums. This confusion of names, due to the great number of the species, and to the application to the same species of different common names by the inhabitants of the various colonies of Australia, makes it impracticable to designate a Eucalyptus tree by a common name. For distinctness it is necessary to use the botanical names almost entirely. It will probably be some time, even in their native home, before these trees have well established popular names for each of the 150 or more species.

In Australia, the different species occupy situations varying from deserts or dry mountainous regions to low, swampy, and moist mountainous ones. On account of the great diversity of species and their wide distribution in their native home, it has been possible to select species suitable to a great variety of

semi-tropic situations; and there are undoubtedly greater future possibilities along this line. Each year one or more additional promising species find their way from Australia to our continent, the usefulness of the genus being thus continually extended to new regions. As Americans become better acquainted with the Eucalypts in their native home the possibilities for the usefulness of these trees upon our continent will be increased.

THE EUCALYPTS AS EXOTICS.

INTRODUCTION OVER THE GLOBE.

From Australia the Eucalypts have been carried to many parts of the earth having a similar climate. The dissemination began on an extensive scale about the middle of the last century, largely through the labours of Baron von Mueller in Australia and of M. Ramel in Australia and in Europe. To be sure, small plantings had been made in Europe and in Africa earlier in the century, but we are indebted to these men for an adequate appreciation of the real merits of the genus.

Others took up the good work in various parts of the world and, during the quarter of a century that followed, the genus became widely distributed. It is said that more trees of this genus have been planted away from its original habitat than of all other forest trees combined. As an indication of how extensively they were being planted a quarter of a century ago, the following statement from a seed catalogue published in Sydney, in 1875, is of interest:—

'To give our friends some idea of the demand: We have sold nearly half a ton of seed during the past year. One pound weight should produce many thousand plants.'

The present generation is reaping the benefit of the extensive planting of that period.

The Eucalypts are now grown successfully in southern Europe, in northern and in southern Africa, in southern Asia, in parts of South America, and in the southern part of North America. Thus, a portion of each continent of the globe is receiving the benefit of the distribution of this useful genus from its native home. In many of the above regions the Eucalypts are a conspicuous feature of the country, the aspect of the landscape having, in some cases, been completely changed by the planting of these trees. There are undoubtedly many other parts of the earth yet to be benefited by the introduction and extensive planting of species adapted to the climatic conditions. The test of various species made in Arizona by the writer, during the past three years, indicate that there are species of Eucalypts adapted to many regions where they have not been tried. These experiments indicate also, that in localities where it has been supposed they could not be grown successfully as forest trees, suitable varieties have not been tried. There is need of a careful study of these trees in their native habitats, in order to determine what species may be introduced into regions with climate and soils similar to those of the districts in which the respective species grow naturally.

IN SOUTHERN EUROPE.

According to Baron von Mueller, Eucalypts were first planted in Europe in the Botanic Garden of Naples, in the early part of the last century. But their value as forest trees was not recognized anywhere in southern Europe until after the middle of the century, and in Italy not till 1870. During the past forty years their culture has increased rapidly. Claude M. Thomas, American Consul at Marseilles in 1894, states, in *Consular Reports*, No. 168, that 'the cultivation of the Eucalyptus is receiving much attention from thoughtful men, wherever in Europe climate and soil are of a character adapted to its growth.'

The French botanists and gardeners were pioneers in studying Eucalypts and in distributing them throughout southern Europe. Their interest seems to have continued unabated for nearly half a century, more publications on the culture and uses of Eucalypts having appeared in the French language during that time than in any other, and probably more than in all other languages in which such treatises have been written. The Eucalypts were introduced into France during or before 1854, and during the succeeding quarter-century were planted extensively.

In France, Eucalyptus culture is still confined almost exclusively to the Mediterranean coast region, no species having been generally introduced that will withstand the frosts that occur at most points to the north of this favoured maritime district. From that country culture has extended into most of the region about the Mediterranean, including its islands. On the island of Corsica these trees have been grown with special appreciation of their value, several publications having been written concerning their culture there.

In Italy, Eucalypts were grown previous to 1870 simply as botanical or ornamental specimens. During that year they were first set in large numbers for the sanitary improvement of a locality. The most extensive planting made that year was by the Trappist monks at Tres Fontane in the Campägna Romana, where malaria was very prevalent.

According to a report made by Herbert W. Bowen, American Consul at Barcelona, in 1894, Eucalypts were introduced into Spain in 1865, where *Eucalyptus globulus* became known as the "fever tree," 'because it is believed to purify boggy and aqueous regions that engender fevers.'

In Portugal and in Greece, Eucalypts are grown successfully, but have not yet been planted on so extensive a scale as in other parts of southern Europe.

IN AFRICA.

About the same time that the Eucalypts were introduced into France they were carried into the French colonies in northern Africa. The Blue Gum (*Eucalyptus globulus*) is reported to have been introduced into Algeria in 1854, a little over half a century after the discovery of the species in Tasmania

by La Billardière. By the year 1875, according to Planchon, it had been planted in northern Africa 'by hundreds of thousands, in groves, in avenues, in groups, in isolated stalks, in every section of three provinces; and the foreigner who does not know the exotic origin of the Eucalyptus would suppose it to be an indigenous tree.' He adds: 'No tree has, in so short a space of time, introduced into the forest vegetation of Algeria so picturesque an element or is as useful and as promising for the future.'

Prof. Louis Trabut, Government Botanist of Algeria, wrote to the author as follows, under date of October 14, 1900:—

'Relative to the Eucalyptus, this tree has been planted in Algeria since 1870. Only *E. globulus* was planted for several years. Lately they have planted *E. rostrata.* These are only the species that have been generally planted. Among amateurs one hundred other species may be found. The Eucalyptus has rendered great service to the country in quickly growing wood for the timbers of sheds and other farm buildings.'

Eucalyptus culture has continued to spread, now extending throughout other parts of the continent, more especially in the English colonies in southern Africa. James Bryce, in his *Impressions of South Africa*, published in 1897, says concerning the planting of Eucalypts in the latter region:—

'The want of forests in South Africa is one of the greatest misfortunes of the country, for it makes timber costly......... Unfortunately, most of the South African trees grow slowly; so where planting has been attempted it is chiefly foreign sorts that are tried. Among these the first place belongs to the Australian gums, because they shoot up faster than any others. One finds them now everywhere, mostly in rows or groups around a house or a hamlet, but sometimes also in regular plantations. They have become a conspicuous feature in the landscape of the veldt plateau, especially in those places where there was no wood, or the little that existed has been destroyed......If this goes on, these Australian immigrants will sensibly affect the aspect of the country, just as they have affected that of the Riviera in south-eastern France, of the Campâgna of Rome, of the rolling tops of the Nilghiri hills in south India.'

IN SOUTHERN ASIA.

It is reported that the Eucalypts were introduced into southern India as early as 1843. Several thousand acres are now covered with these trees, principally upon the Nilghiri and Palui hills. In parts of India a great variety of Eucalypts thrive, while in other sections only a limited number of species can be grown. Some large plantations there are now forty years old. In the Consular Report for September, 1894, V. L. Polk, then Consul-General at Calcutta, remarks concerning the Blue Gum (*Eucalyptus globulus*), 'it may be said generally that the growth of this species is an unqualified success.'

IN SOUTH AMERICA.

The Eucalypts have been grown in parts of South America for over thirty years. Interest in them in the Argentine Republic was aroused by the careful work of Dr. Ernest A. Berg, who conducted cultural experiments with the genus and in 1874 published a work upon the importance of these trees for a wood supply. They are grown to some extent in Peru, in Venezuela, and in other parts of the continent.

IN NORTH AMERICA.

The Eucalypts were introduced into North America only a few years after their introduction into France and Algeria, the merits of the genus being early recognized by Californians. It is reported that they were introduced into California in 1856 by Mr. Walker, of San Francisco, and in that year fourteen species were planted. In 1860, Mr. Stephen Nolan, a pioneer nurseryman of Oakland, being greatly impressed with the rapid growth of these first trees, and also with their evident adaptability to the climate, commissioned a sea captain sailing for Australian ports to secure any Eucalyptus seed he could, at the same time furnishing money with which to make the purchase. A large supply of seed of several species, including *Eucalyptus viminalis*, was received from this source, and sown in 1861. Mr. Nolan continued to import seed in quantity for several years, distributing the seedlings widely through the State.

The country is specially indebted to the Hon. Ellwood Cooper for calling attention to the merits of the Eucalypts. For many years he was very active in bringing the genus to the attention of the citizens of California. In 1875, he delivered, in Santa Barbara, a lecture in which his enthusiasm for the genus found expression. This was probably the first address on the subject in America. His interest in these trees (and, incidentally, the rapidity of their growth, which is one of the causes of their rapid introduction) is shown by the following statement made by him upon that occasion:—

'At my home I have growing about 50,000 trees. The oldest was transplanted three years ago. A tree, three years and two months from the seed, transplanted two years and ten months ago, is 9½ inches in diameter and 42 feet 6 inches high.'

During the intervening quarter century Mr. Cooper has continued the extensive planting of Eucalypts. He has set them in canyons and on steep hillsides, has utilized them for a forest cover, for wind-breaks, for shade on avenues, for sources of timber and wood, as well as for ornament, thus furnishing the country an object lesson of what the tree will do for an appreciative planter. He now has about 200 acres of his ranch north of Santa Barbara covered with forests of these trees.

A great impetus has been given to the planting of Eucalypts in the south-western United States by the labours of the Hon. Abbot Kinney, of Los Angeles. As chairman of the California Board of Forestry from 1886 to 1888, he rendered

a great service to the State in causing the planting of thousands of Eucalypts within her borders. A large percentage of the trees, of species other than *Eucalyptus globulus*, now growing in the south-west, are from plants distributed during his administration. Mr. Kinney has ever since been an enthusiastic student and planter of trees of this genus, and has written more upon Eucalypts than any other American. In Southern California especially, and in Arizona also, the planting of these trees has been extended very much by his work.

During recent years, the planting of Eucalypts has been stimulated by the labours of Mr. A. Campbell-Johnston, of Garvanza, Cal., an ardent student and admirer of these trees, who, by his writings and his example, has done much to attract attention to the merits of the genus. The firm with which he is connected at South Pasadena, Cal., is rendering a service of incalculable value in furnishing for planting authentically named seedling Eucalypts. Mr. Campbell-Johnston is also conducting at his ranch the most extensive cultural tests of species of Eucalyptus that have been made in America.

It is through the labour of such men as have been mentioned that the Eucalypts have become disseminated and recognized and very generally planted throughout California. The landscape of many parts of the State has been completely changed by the growth of these trees. Over much of the State they are the principal wind-break, shade, and fuel trees, and the number of useful purposes they serve is continually increasing. Without the Eucalypts, California would be a very different State and their value to the commonwealth is beyond calculation.

From California the planting of Eucalpyts extended into Arizona, New Mexico, Texas, and Florida. In most cases the Blue Gum (*Eucalyptus globulus*), the species that had been most successfully grown in California, was the one first planted in these regions. The Blue Gum is not adapted to these regions and this has led to the belief that no Eucalypts would thrive there. In Southern Arizona, for example, the Blue Gum does not endure the dry heat of summer, while in Florida the frosts of winter have been fatal to it. But in some of these places more resistant species have been introduced and are growing satisfactorily. A more careful and systematic study of the genus accompanied by cultural tests, would undoubtedly result in the discovery of additional and probably better species for these and other regions.

Eucalypts have been introduced from California into Mexico also, and their merits are being gradually recognized there.

The introduction of heretofore untried species is continuing in the south-west, and the number grown there is thus rapidly increasing. During the past three or four years especially, a great many species have been added to the list of those grown in America. The recently introduced species are growing mostly at the University of California, at forestry stations at Santa Monica and Chico, on the ranch of A. Campbell-Johnston (Garvanza), in Elysian Park (Los Angeles), and upon the experiment station farm near Phoenix. Their

development is being closely watched by those interested in their planting, and by whom the great future possibilities in these recent arrivals from the native home of the genus is fully realized.

GENERAL CHARACTERISTICS OF THE GENUS *EUCALYPTUS*.

The genus Eucalyptus includes about 150 species. Most of them are trees of large size; some of them among the largest in the world. They range, however, from immense trees towering high on plains and hillsides down to small shrubs that cover desert or alpine regions.

They grow in a great variety of soils and climates, the various native environments having thus resulted in the development of species that are quite different from one another. In their native home they grow both scattered and in forests.

The Eucalypts are all evergreens, a fact that should be taken into consideration when planting them.

Many of the species are vigorous growers, a few being specially noted for the great rapidity of their growth. The Blue Gum (*Eucalyptus globulus*) is one of the fastest growing of the genus. On the ranch of Hon. Ellwood Cooper, near Santa Barbara, Cal., trees of this species 25 years old are as large as oaks whose rings show them to be 200 to 300 years old. As to their growth in France, Prof. Charles Naudin, in his memoir on Eucalyptus, published in 1891, says:—

'In a score of years they [the Blue Gums] attain at least the volume and the height of an oak a century old. Some others, though not growing as rapidly, are moreover remarkable for the short time in which they may be used for carpentry, for joinery, for carriage making, for agricultural implements, for railroad sleepers, and for telegraph poles.'

It is this rapidity of growth, enabling them to reach the stature of trees in a few years, that has been the principal cause of the popularity of the Eucalypts where they have been introduced.

Most species if pruned, or if cut off at the ground, sprout freely, sending up shoots that usually make a very vigorous growth. This makes it possible to cut the trees for fuel, for timber, or for other purposes, and in a comparatively short time to again have a forest containing as much timber as before the trees were cut. A Blue Gum (*Eucalyptus globulus*) eight to ten years old, if cut to the ground, will send up shoots that will reach a height of 75 or 100 feet in from six to eight years. Several other species make an almost equally rapid growth after being cut. The cutting may be repeated every few years for an indefinite period.

Eucalypts are propagated only from seed. To this fact is due their comparative freedom from injurious insects and from diseases usual to exotics which have been introduced into America by cuttings or seedlings. Their dissemination through the world having been by seeds alone, the insect enemies and

the parasitic fungi of their native home have been left behind. In America, they have few insect enemies, and they are remarkably free from disease.

RELATION OF THE EUCALYPTS TO CLIMATE.

GENERAL CLIMATIC REQUIREMENTS.

The Eucalypts differ considerably as to the climatic conditions under which they thrive, but all the larger arboreal forms agree in requiring a warm climate. Not only do they prefer a climate that is equable, but other conditions must exist in order that they may be grown successfully. Prof. Charles Naudin, in his memoir on the genus, gives concisely the conditions required for the successful growth of Eucalypts. He says :—

'The first condition of success in the culture of Eucalypts is a climate appropriate to their nature ; that is to say, for a great majority of the species, warm summers, a moderate amount of rain, a certain atmospheric dryness, plenty of sunlight, and very temperate winters.'

While all thrive best in regions with warm summers, many species do not endure the summer heat of certain sections of south-western North America. Regions where the midsummer maximum temperatures range from 88° to 105° F. are best suited to the growth of these trees. Some species thrive in regions where the maximum temperatures range in summer from 100° to 120° F., but the number is limited. The various species differ very much as to the amount of cold they will endure. Some will stand minimum temperatures of 10° to 15° F., while other species will, under no circumstances, endure temperatures much below freezing. The degree of cold that any species will endure depends not only upon the other conditions of the atmosphere at the time, but upon the nature of the weather that has preceded. Low temperatures following a warm period that has stimulated growth do much more injury than the same degree of cold following a gradual fall in the temperature.

While most Eucalypts are benefited by occasional heavy rainfalls that saturate the soil thoroughly, frequent rains and a very humid atmosphere are not conducive to their healthful growth. They have the power of absorbing great quantities of water by means of their roots, but the above-ground parts of most species prefer to be in quite dry atmosphere, at least for a portion of the year. A few species grow in swampy, humid regions, but the majority of them prefer drier situations. Plenty of sunlight is quite essential to the healthy growth of most species, few of them thriving in the shade of other trees or in regions having much cloudy weather.

CLIMATIC AREAS IN NORTH AMERICA.

With regard to the effect of climate upon the Eucalypts, we may divide the United States into four sections. In the first and largest divisions the winters are ordinarily so cold as

to kill the Eucalypts, and their growth there outdoors is consequently impracticable. This region comprises all of the United States except a strip varying from 100 to 300 miles in breadth along the southern and south-western border.

In the second division, the winters in most years are so mild that growth is not checked; but, during some winters, a cold wave passes over the region that kills the whole, or a large part of the tree that has grown during the years in which no unusually cold period occurred. In this section Eucalypts never, or rarely, become dormant; and when a cold wave comes they are unprepared for it, the result being disastrous. This region consists of Florida and the adjacent coast region of the South Atlantic and the Gulf of Mexico. In Florida the conditions seem to be specially trying. Possibly there may be a species as yet untried there, that would withstand the conditions described.

In the third division, the minimum temperatures, while commonly quite low during midwinter, decrease so gradually during the latter part of autumn that the growth of the previous year has time to mature. It is thus able to endure a low temperature that would be fatal in the second division, discussed above, where the weather is alternately warm and cold.

In the fourth division the climate is so equable that nearly all species of the genus Eucalyptus will grow in it. In this region the mercury rarely falls below 25° F. during winter nor rises much above 105° F. during summer, and the atmosphere is commonly moderately humid. This division consists of the coast region of central and southern California. It is the section of the United States in which Eucalypts are grown most extensively and most successfully.

Mexico might be similarly divided into four Eucalypt areas. The territory of these divisions would not necessarily be contiguous, but would be determined by elevation rather than by latitude or longitude.

USES OF EUCALYPTS.

The Eucalypts probably serve more useful purposes than the trees of any other genus grown on the globe, except, possibly, the various palms. Their uses are very diverse. As they grow, they serve as a forest cover to mountains, hills, plains, and swamps; as wind-breaks; and as shade trees. While growing, they are also the source of many gums and resins, and of honey. When cut, they furnish valuable timber, excellent fuel, and a very useful oil. Besides all this, many of them are ornamental and they have the reputation of improving the climate of the region in which they grow. Being hardwood trees, they serve the useful purposes that hardwood trees ordinarily serve, and, besides, furnish many useful products similar to those obtained from a variety of other trees, and from shrubs and herbs. This great variety of uses is made available, in regions where they have but recently been introduced, by reason of their very rapid growth, it being possible to enjoy many of their uses while the trees are still

standing, and to obtain from them many useful products within a very few years after planting them.

AS A FOREST COVER.

It is as forest trees that the Eucalypts are most useful; planted as ornamental or as shade trees they are often disappointing. Planters who have put them out as forest trees are the ones who have derived the greatest benefit from them. The Hon. Ellwood Cooper, of Santa Barbara, was one of the first Americans to recognize the prospective value of Eucalypts as forest trees. He acted upon his conviction, and has for a score of years been reaping the reward. Besides enjoying the shade and beauty of his groves as well as the beneficial changes they have wrought in the climate of the region, he has for many years received from them an annual income of no inconsiderable amount. Those who have planted them singly or in small groups as ornamental or shade trees have received little or no financial return, and have in some cases been disappointed in them because not serving, as they had hoped. the purpose for which they were set.

In many of the semi-tropic portions of the globe the Eucalypts are the trees most suitable to plant for forest cover. Much of the treeless land of semi-tropic America might be covered with these trees. As the conditions under which the different Eucalypts grow in Australia are very diverse, it is evident that, if the species are properly selected, they will cover nearly all kinds of situations.

The species that grow in Australia on the uplands and in other dry situations can be used here to cover similar regions. In the south-west there are large areas of hilly country, of little or no use for other purposes, that might be transformed into useful forests by covering them with these trees. This covering of the hills with forests will not only furnish shade. a source of honey and a supply of fuel and timber, but will prevent the too rapid run-off of rain water, which results in the cutting and washing of hillsides and in other forms of damage below. On this point Mr. Cooper, in a letter to the writer dated June 18, 1900, says :--

'South of where I live, about one-eighth of a mile, is a steep hillside. I noticed, during my residence the first years, that heavy rains washed down the soil, all the rain running off. I planted Eucalyptus trees on this hillside, about 4 feet apart. When these trees had four or five years of growth we had a tremendous rain storm, 14 inches of rain falling in four days. Nearly all this water was held by the trees, practically none running off. There is always more moisture in the soil near these trees than some distance off. There is no question as to the great importance of having our mountain sides well wooded with trees and bushes to preserve the rain for the benefit of the valley below.'

The Eucalypts can be utilized as a forest cover for mountains as well as hillsides. Several species grow naturally upon the mountains of Australia. These will serve as a covering

for bare mountain sides in the south-west, and the writer believes that they would prove quite valuable for recovering those that have been denuded of their natural forests by fire. The rapid growing species, less resistant to frost, could be planted on the lower parts of the mountains, and the somewhat slower-growing, more hardy ones farther up the mountain sides. Those adapted to alpine situations may be planted to a height of from 4,000 to 6,000 feet.

Lowlands, too, may be covered with Eucalypts. In Australia several species grow naturally in swamps or other low situations. These may be utilized for covering the lowlands in warm regions in other parts of the world, thus reducing the amount of stagnant water, and in other ways rendering such localities more agreeable.

AS WIND-BREAKS.

In the south-west the Eucalypts have been found very useful as wind-breaks. Their quick growth and varied habit make them peculiarly adapted for this purpose. Thus, a low tree with dense foliage may be selected where a low, close wind-break is desired, and a taller species where a higher and less dense shelter is needed. Owners of orchards, especially citrus orchards, have found them particularly beneficial as a break to the strong winds.

On this point Mr. Nathan W. Blanchard, of Santa Paula, one of the most extensive growers of citrus fruits in California, in a letter dated June 11, 1900, makes the following statement:—

'In reference to Blue Gum wind-breaks, I prefer them to any other. They grow rapidly and break the force of the wind, which is what is required. A solid wind-break like a Monterey Cypress, the wind sometimes falls over and has a twisting effect on the trees, similar to wind coming from a high mountain range. With my experience in this valley I would plant the wind-breaks about 450 feet apart.

'The Limoneira orchards are laid off in sections, putting the Blue Gum 40 rods apart, but I think this distance is too great and it is too far to run the water economically. My wind-breaks are about 450 feet apart, and are so effective that one does not feel the wind at all among the orange trees. Neither is my fruit in the least impaired by the wind, however strong it may blow down or up the valley. My orchard ditches are along the wind-breaks, and the trees therefore get all the water that they need and do not draw upon the moisture of the orchard to the detriment of the fruit trees. Indeed, I have some orange trees alive that are growing right under the Blue Gums, bearing some good fruit. If the Blue Gums are sufficiently supplied with water they have no injurious effect upon the trees other than the shade, and on the east side of the wind-breaks my trees are more thrifty, or at least bear more fruit, than the average, while on the west side the shade is somewhat detrimental to the amount of fruit that I secure.'

Upon the above subject Mr. Ellwood Cooper, of Santa

Barbara, in the letter previously mentioned, writes as follows: –

'The fruit orchards where protected have larger growth and cleaner leaves and stems. Less fruit blows off during high winds. I know of an orange orchard at Santa Paula where Eucalyptus trees were planted on the east and west sides—quite a distance between. The trees on either side, where protected, were twice as large as those in the centre; in fact the orchard was sloping from the protected sides to the centre. The centre rows were taken out and Eucalyptus trees planted. The orchard now shows a uniform appearance.'

AS SHADE TREES.

While many of the Eucalypts are not especially desirable shade trees, the fact that they will grow well in many situations where other trees make poor growth, or will scarcely grow at all, gives them considerable value for this purpose. They are especially suitable for country roads, for the vicinity of barns and other farm buildings, and for shade in pastures. As road shade trees, many species have proved very useful in the south-west and have been much used for this purpose. Mr. Cooper, in a letter already mentioned, writes upon this point as follows:—

'The public highway through my ranch, seven-eighths of a mile in length, has a double row of trees on either side. There is less mud in winter and less dust in summer than on the road at either approach.'

The writer observed the latter fact while there during August. In regions where there is less sunshine and more rainfall than there is at Santa Barbara, it might be well to plant the trees farther apart on the sunnier side of the road to permit the road to dry after rains. In many cases the trees can be so set along the road as to serve both as a wind-break against the most disagreeable winds of the region and as shade trees during summer. In all cases, the fact that these trees are evergreen, and consequently shade-producing both winter and summer, must be taken into consideration. In regions where heavy winter rains occur, it would not be wise to plant Eucalypts so thickly as to keep the road from drying.

AS A SOURCE OF TIMBER.

For Australia and the neighbouring islands the Eucalypts are one of the important sources of general timber supply, and are the chief source of the hardwood timber used there. The uses made of Eucalyptus timber are remarkably diverse. It enters into the construction of buildings, ships, bridges, railroads, piers, telegraph lines, fences, paving, vehicles, agricultural implements, furniture, barrels, and a great variety of minor articles. In his *Notes on the Commercial Timbers of New South Wales*, Mr. Maiden names twenty-five 'special purposes' for which the timber of Eucalypts is used in that colony. Six species are named as valuable for bridge timbers, five as valuable for piles, nine for paving, eight for posts, three for railroad ties, four for railway coaches, five for lumber and

shingle, seven for the various parts of vehicles, two for barrels and casks, and two for broom and tool handles. Eleven 'special purposes' are assigned to the timber of the Spotted Gum (*Eucalyptus maculata)*, ten to the timber of the Ironbark (*E. sideroxylon*), eight to that of Red Mahogany (*E. resinifera*), and Tallow Wood (*E. microcorys*), six to that of Gray Gum (*E. propinqua)*, five to that of Red Gum (*E. rostrata*), and a lesser number to that of seven other species. Not only in Australia is the timber of Eucalypts used thus extensively, but it is exported in large quantities, the bulk of the hardwood lumber shipped being from these trees. R. Dalyrimple Hay, in his work entitled *The Timber Trade of New South Wales*, names thirteen species that furnish timber for export. He gives the annual output of lumber from the 108 mills of the colony as 59,500,000 superficial feet, a large part of which is from Eucalypt trees. Shipments are made to distant parts of the globe, including Africa and even England.

The timber of different species of Eucalypts differs very much in character. While that of all species is hardwood, the degree of hardness, the strength, durability, flexibility, colour, and many other qualities are quite different. Great differences exist also in the timber of the same species grown in different soils and climates. To these variations is due largely the great variety of uses that the timber of these trees serve.

In America the Eucalypts have not yet been grown long enough, nor extensively enough, to have become a source of lumber. The principal uses made of the timber thus far are for fuel, piles, posts, and some of the parts of farming implements, and for pins for insulators on long-distance transmission cables. The species used most for piles in Southern Australia does not thrive in the south-west, but the Blue Gum has been found to be a very durable substitute. The life of Redwood (*Sequoia sempervirens*) and of Oregon Pine *(Pseudotsuga taxifolia*) piles is from four to seven years on the Pacific coast. Blue Gum piles last twice as long. The piers at Santa Barbara and at neighbouring sea towns are maintained with piles of this Eucalypt. Mr. Cooper informs the writer that he has sold from his groves nearly $10,000 worth of piles during the past ten years. At Oceanside the superior value of Eucalypt piles is reported to have been demonstrated through the surreptitious acts of a contractor. Lacking a few piles of the timber specified in the contract (Oregon Pine), he is said to have obtained some Blue Gum timbers from the vicinity and to have ordered the night crew to place them on the inside, where their presence would not be detected. When it became necessary to repair the pier, a few years ago, some sound piles were found among others nearly destroyed, and upon examination they proved to be the Blue Gum trees. The demand for these piles is now greater than the existing groves of Eucalypts can supply. It seems probable that piles may become one of the important crops grown by farmers of the south-west. As the trees now planted become larger, and as planting becomes more extensive, the Eucalypts will undoubtedy become sources of much timber for a great variety of purposes.

AS A SOURCE OF FUEL.

In Australia the Eucalypts are an important source of fuel. There the inhabitants find the trees ready grown for use, and it matters little to them how long they have taken to reach their present size. Hence many species are used for this purpose. In America and other countries where the Eucalypts are grown as exotics the case is quite different. Only a quick-growing species will yield an early supply of fuel, and hence the Blue Gum among the Eucalypts has been most used for this purpose.

The Manna Gum (*Eucalyptus viminalis*), the species approaching the Blue Gum most closely in rapidity of growth, has also been cut considerably for fuel. Other species making a slower growth produce a harder wood and better fuel. For some years Mr. Cooper has been cutting stove wood for the Santa Barbara market from his Red Gum (*E. rostrata*) and Red Ironbark (*E. sideroxylon*) groves, and finds the fuel from them superior to that from the Blue Gum. When other species become more generally known, or when plantings now made have reached a sufficient age, undoubtedly several species will be found better adapted for fuel than the now much used Blue Gum. But at present that is the fuel tree of much of the State of California.

When set for fuel the young trees are commonly planted either 8 by 8 or 6 by 10 feet apart. Rows 10 feet apart, with trees 6 feet apart in the rows, give a few more trees to the acre, and leave more space between the rows for driving with a wagon. Formerly some growers planted closer—either 4 by 4 or 4 by 8 feet—and cut out the trees as they increased in size until they were left the distance apart they desired them to be permanently. But so much difficulty was experienced in preventing the growth of the trees desired to be eliminated that the practice has been almost entirely abandoned. The young trees are commonly cultivated for about two years after being set out.

In California some of the best agricultural land is used for growing Blue Gum wood for market, usually in groves of from 10 to 40 acres. Not only are these groves profitable, but they add much to a landscape which without them was quite monotonous. Land unsuitable for tillage—hillsides, ravines, and rocky plains—is also much utilized. In such cases the return from the fuel produced is practically a clear gain.

When five to seven years old, groves of Blue Gum or Manna Gum may be cut to the ground for fuel, and they may be cut every six or eight years thereafter. The yield from each cutting is commonly 50 to 75 cords of 4-foot wood per acre. One 17-acre grove between Los Angeles and Compton, set in 1880 and cut for the third time in June, 1900, produced 1,360 cords, an average of 80 cords of 4-foot wood per acre. The price received by the owner for the crop was $2·50 per cord on the stump. It will be seen that this return fully justified the using of the heaviest of agricultural land for the growth of fuel. On poorer land the yield is only a third to a half the above amount. The size

attained in good soil a short time after being cut is often remarkable. In a grove near Pasadena, set in 1885, and cut for fuel in 1893, there were in July 1900, some trees 2 feet in diameter and many over 100 feet in height.

Mr .Cooper estimates that, at the rate his trees are growing, he can cut from his 200 acres of miscellaneous species, set largely in soil too rough for tillage, 1,000 cords of wood per year indefinitely, without in any way detracting from the appearance of the groves or from their usefulness in other ways. Judged by the known rate of growth of smaller groves the above estimate is not high.

Not only the wood of the Eucalypts is used for fuel, but, in California, the leaves are utilized for this purpose. A Los Angeles company is making, for market, bricks composed of Blue Gum leaves and twigs mixed with crude oil, and the product is reported to be an excellent fuel for domestic use. The entire tree is thus utilized. This new use of Eucalypt leaves suggests the possibility of many industries growing out of the extensive planting of the trees in the south-west.

AS A SOURCE OF OIL.

While the stem and branches of the Eucalypts furnish timber and fuel, the leaves and twigs are the source of a very important oil. In Australia, many species yield sufficient quantities to enable them to be utilized for oil production, but most of the oil produced there is obtained from three or four species. For many years the production of eucalyptus oil has been an important industry in that country. One of the first investigators and producers of this oil was J. Bosisto, of Melbourne. Baron von Mueller states in the *Eucalyptographia*. that, in 1880, Bosisto was producing 6 tons of oil per year. Since then the demand for the oil has increased very much, and a much larger quantity is produced in Australia annually. During the past ten years a large quantity of eucalyptus oil has been produced from the Blue Gum plantations in Algeria, it having been found advantageous to obtain the oil from solid plantations of one species rather than from native forests where the species grow mixed. In California, a large amount of oil has been extracted from the Blue Gum during the past five years. The principal producer is a physician in Los Angeles, who is attempting to establish a reputation for putting up a pure, high-grade product. During the winter of 1900-1 he extracted 9 tons of oil. He does not distil out any eucalyptol, as he considers the oil in the form he puts it out superior for most purposes. The residue after the refined oil has been distilled off from the crude product is put up for a salve. From the oil he manufactures a soap and cough drops. The Hon. Ellwood Cooper has a young Blue Gum plantation on his ranch near Santa Barbara, from which he intends to manufacture both eucalyptus oil and eucalyptol. He will cut the trunk and limbs into fuel, extract oil from the twigs and leaves, and thus utilize the entire tree.

The different species vary greatly as to the amount of oil they will yield, the range being from none to 500 ounces from

1,000℔ of fresh leaves and twigs. According to J. Bosisto and other Australian authorities, and S. M. Woodbridge, of Los Angeles, the Peppermint tree (*Eucalyptus amygdalina*) yields the largest amount. But in America this tree is not grown extensively enough for it to be a source of much oil. For some years yet, and perhaps always, the chief source of eucalyptus oil here will be the Blue Gum. The yield of crude oil from the leaves and twigs of this species ranges from 1 to 1·6 per cent. Dr. Herron extracted, during the past season, 9 tons of oil from 700 tons of leaves and twigs from this species—a yield of 1·28 per cent. H. B. Silkwood, proprietor of the California Eucalyptus Works, Garden Grove, Cal., reports that he produced 1 ton of oil from 100 tons of material during the past year, the output being limited by the available supply of Blue Gum leaves. The Red Gum yields much less oil than the Blue Gum —only 10 to 30 per cent. as much.

The oils from the different species of Eucalypts differ greatly. As extracted they are all compounds or mixtures. The chief ingredient of the oil from the Blue Gum is a colourless, transparent, camphoraceous liquid called eucalyptol or cineol: of the Peppermint tree (*Eucalyptus amygdalina*), a less known liquid called phellandrene; of the Lemon-scented Eucalypt (*E. citriodora*), a fragrant, highly volatile liquid called citronellon, mixed with another fragrant liquid called geraniol. Several other ingredients enter into the composition of the oils from the various species. The best known of all the ingredients is eucalyptol, which contributes about 60 per cent. of the oil from the Blue Gum.

The medicinal properties of the various component parts of eucalyptus oil differ widely. Hence the oils from the different species have very different medicinal values. Unless eucalyptol, the chief ingredient of Blue Gum oil, has the same effect upon the human system as phellandrene, the prominent ingredient of the Peppermint tree oil, the oils from these two trees must necessarily have different medicinal properties, and the oil from a forest of mixed species must have very uncertain medicinal properties. The eucalyptus oil produced in America, where the groves from which leaves are obtained for oil are commonly of one species, and where, with rare exceptions, a single species (Blue Gum) is the source of all the oil extracted, will necessarily be a product whose properties are better known and more constant than that produced from mixed native forests. Hence the importation of eucalyptol or eucalyptus oil from Australia or elsewhere is both unnecessary and a disadvantage to the consumer. As the Hon. Abbott Kinney remarks in his *Eucalyptus*:—

'The increased use of eucalyptus oils, derived from the solid plantations of *E. globulus* in California and Algiers, is thus seen to rest upon reasonable grounds and must give increased reliability to medicinal preparations from the Eucalyptus.'

Eucalyptus oil has been used for about forty years, but only during the past ten years has it been employed in medicine very extensively. Its use is now constantly increasing, as its properties and medicinal value become better known. All

druggists questioned on the subject stated that the demand for eucalyptus oil was rapidly increasing. Two wholesale druggists of Los Angeles both stated in letters to the writer, written in response to inquiries on this point, that their sales of the oil had increased very much during the past few years.

The fact that the oil is non-poisonous and non-irritant makes it especially safe and valuable. As much as one-fourth of an ounce has been taken internally without injury, and it may be freely applied to the most delicate tissue. Notwithstanding the fact that it is neither dangerously poisonous nor irritating to the human system, it is a very effective antiseptic and disinfectant, and has come to be used quite extensively for dressing wounds, ulcers, and other diseased tissues. It enters into the composition of several antiseptic preparations. The oil is also a well-known remedy for malarial and other fevers, and is used in treating diseases of the skin, of the stomach, kidneys, and bladder, and is especially valuable for affections of the throat, bronchi and lungs.

In using eucalyptus oil it is most important that a pure article be procured. Unfortunately there is considerable adulteration of this oil with cheaper, inert, or harmful ones. No doubt this remedy would be a more popular one but for the fact that so much of the oil for sale on the market is of such an uncertain nature. The safest way is to purchase none in bulk, but buy it in bottles put up by a reliable person or firm. It costs more in this form but is far safer to use as a remedy.

The leaves of the Blue Gum and of a few other species, on account of the oil they contain, are employed as household remedies in localities where the trees grow. Among the natives of Australia, they are said to be in common use for dressing wounds and for other purposes. In California, teas and poultices are made from the Blue Gum leaves for treating colds, wounds and ulcers. The leaves are also steamed for the treatment of colds, catarrh, croup, bronchitis and other affections of the respiratory system. Some go so far as to use, regularly, tea made from the leaves of Blue Gum, and, as they assert, with beneficial results.

AS A SOURCE OF HONEY.

The Eucalypts generally bloom so freely and so early in their development that, as a group, they are an important source of nectar for bees. The fact that some species can be found in bloom any day of the year, often during droughts when other blossoms are scarce, in many cases in great profusion, makes them especially valuable as a constant source of bee food. Mr. Kidney, who has made extended observations on the blooming of the Eucalypts, writes in his *Eucalyptus* :—

'Taking the sixty species and marked varieties of this genus in southern California, I have never seen a day that flowers could not be found on some of them. . . When we consider the free production of nectar by the Eucalyptus at seasons when there is little or no other resource for bees, and also the claimed medicinal value of honey from Eucalyptus flowers for relieving

irritation from the mucous membrane, and as a nerve sedative, the presumption is strongly in its favour. Bee-keepers will doubtless find it to their interest to study the species and plant in waste places such sorts as will furnish the best kinds of nectar during the most difficult seasons for the bees. . . I believe that, by some study of this subject, species of Eucalyptus with plenty of nectar could be so selected as to give a constant crop of flowers, or give flowers at such times as these are absent in other plants.'

Whether or not the Eucalypts give a peculiar medicinal quality to the honey may be a question, but it is certain that they are a valuable pasture for the bees. In planting trees for forest cover, wind-breaks, shade, timber or fuel, it would be well, wherever the bee industry is important, to select varieties recognized as flower producers. Several species, notably the Sugar Gum (*Eucalyptus corynocalyx*), the Red Gum (*E. rostrata*), the Red Ironbark (*E. sideroxylon*), *E. hemiphloia*, and *E. polyanthema*, are profuse bloomers and are thronged with bees during the blooming season which, with some species, is quite protracted.

AS IMPROVERS OF CLIMATE.

The Eucalypts have the reputation of benefiting the climate of those regions where they have been planted. Evidence upon this subject is so conflicting, however, that the truth is ascertained with difficulty. Whatever the fact may be, the belief is quite general, especially in southern Europe, that the effect of Eucalypts upon the climate is distinctly sanitary.

The plantation of Eucalypts at Tres Fontane, in the Roman Campãgna, is the instance most generally cited by those who contend for the beneficial influence of these trees on the climate. In fact, the general planting of Eucalypts throughout southern Europe seems to have been given a decided impetus by reports of the results at Tres Fontane. On this point Charles Belmont Davis, American Consul at Florence in 1894, writes in *Consular Reports*, No. 168, as follows :—

'It is this latter quality [the property of distributing a balsamic atmosphere] which has brought the Eucalyptus into such prominence in Italy, and has been the cause not only of the planting of thousands of trees by private individuals and public corporations, but of its receiving the indorsement of the Italian Government as well.'

M. Carlotti, who has studied Eucalypts exhaustively on the island of Corsica, in his *Rendering warm, unhealthy regions healthy by means of the Eucalyptus*, cites a large number of instances of improved climate attributed to the planting of Eucalypts.

M. Lambert makes similar statements as to the effect of planting these trees in Algeria. M. Gimbert also cites examples of the improvement of climate in Algeria, as well as in Cape Colony and other parts of Africa, due to the planting of Euca-

lypts. It is asserted by many Californians that the planting of Eucalypts has diminished the amount of malaria in central California. Others in various parts of the world have made similar claims.

On the other hand, some who have investigated the subject maintain that the fact of the improvement of climate by Eucalypts is not established. Perhaps the ablest of those who have combated the popular belief in the sanitary effect of Eucalypts is Prof. Tomaso Crudeli, who has investigated the subject carefully in Italy. He insists that, up to the date of his writing (1886), 'not a single instance of hygienic improvement by the sole means of Eucalypti has been ascertained, but the possibility of so doing is not denied.'

Wallace S. Jones, American Consul at Rome in 1894, writes as follows in *Consular Reports*, No. 168 :

'In Italy, although the newspapers had persuaded everyone that the farm of the Tres Fontane, near Rome, had become healthful by means of the Eucalypti, it proved a disagreeable surprise to learn of a sudden outbreak of malaria in 1882 that caused much sickness among the farm hands, while the rest of the Campàgna remained perfectly healthy . . . . Dr. Montechiare, a practising physician of Rome, who for years was physician to the penal colony at Tres Fontane, tells me that his experience justifies him in declaring that no beneficial result against malaria has been derived from the planting of the Eucalyptus.'

Those who fail to recognize the beneficial effects of the planting of Eucalypts also call attention to the fact that malaria prevails in many parts of Australia where these trees are abundant. It seems to be admitted, however, that malaria is absent, or at least not prevalent, in those parts of Australia where the Blue Gum, the species that is believed to have produced the beneficial result about the Mediterranean, is native or thrives. Whether this coincidence, if such it be, is due to the natural climate or to the effects of these trees, would be somewhat difficult to decide.

It is probable that a great part of the change in the sanitary condition of those places, said to have been benefited by Eucalypts, has been due to other causes, such as the making of drainage ditches, etc., and this will partially account for the conflicting opinions on the subject. When, however, the nature and habit of the trees are considered, it is entirely reasonable to believe that, to a certain extent, they beneficially affect the atmosphere in the region of their growth. The grounds for this belief are : First, their great capacity for absorbing moisture from the soil, and thus reducing the quantity of stagnant water in the ground at their roots ; second, their corresponding power of giving off fresh from their foliage the water thus taken up by their roots ; third, the exhalation from their leaves and other parts of volatile oils, which affect the climate not only directly but by changing the oxygen of the atmosphere to ozone ; fourth, the purification of germ-infested matter by the foliage dropped upon the ground or in pools of standing water. From the combined action of these four characteristics it seems reasonable to believe that the trees would be beneficial to many climates.

It is not necessary to determine, however, before setting Eucalypts, whether they have a pronounced beneficial effect upon the climate or not. They certainly do not injure a climate. They serve so many other useful purposes that the question as to their effect upon climate may be waived, and the planting of them still go on from other motives. Eucalypts may confidently be grown for a forest cover, for wind-breaks, for shade, for timber, for fuel, for the oil and the honey they furnish, and if, at the same time, they improve the sanitary condition of the region in which they are growing, the reward of the planter will be so much the greater.

PROPAGATION AND CARE OF EUCALYPTS.

PLANTING THE SEED.

The usual method of starting Eucalypts is to sow the seed in shallow boxes in specially prepared soil. A mixture of coarse sand and leaf mould (two parts of mould to one of sand) is the best. This is placed in boxes a few inches deep; the seed is strewn quite thickly over the surface; a light covering of sand is placed on top, and this surface is then kept constantly moist. The young plants commonly appear in one or two weeks. After germination has taken place, the soil should be kept moist but not wet. If kept too damp the young plants will be attacked by parasitic fungi and perish rapidly—'damp off,' as gardeners term it. Applying the water about the middle of the forenoon, so that the soil and plants have time to become partially dry before night, is a precaution helpful in preventing damping off. In the experience of the writer there is nothing better for freshly sown seed, or for young plants, than a watering by a rainfall. Leaving the seed boxes out during a light rain will often start seed that artificial watering for weeks has failed to bring up, and young plants are very much refreshed and invigorated by a shower of rain.

Before transplanting, it is well to harden the young plants by giving them only sufficient water to prevent wilting during the heat of the day. After a week or so, when they have become more woody, water should be applied freely for a few days, and they will then be in a better condition for transplanting than if this treatment be omitted.

TRANSFERRING TO FRESH SOIL.

When the young seedlings are 2 or 3 inches high, they should be transplanted into flats of fresh soil, putting in the plants about 2 inches apart each way. This soil may contain less sand and more leaf mould than the seed bed. A mixture of leaf mould, sand and some soil similar to that in which they are to be set in the field is a good combination. If the plants are few and choice, it is usually best to transfer them from the seed beds to pots instead of to flats. From the pots they can be transplanted with less loss than from the boxes. They still need frequent watering, but the surface of the soil does not need to be kept so moist as during the earlier stages of growth. For

a few days after being transferred, they often need additional protection from drying. When they have become well established, it is well to expose them to the sun and the outdoor air sufficiently to harden them before transplanting to the field.

The work of propagating Eucalypt seedlings is not always accomplished successfully by those without experience in gardening or greenhouse work. Where the climatic conditions are at all trying, unless one has had some experience in propagating evergreen plants from small seeds, it will be better to purchase the trees of a grower. So many are lost from various causes, that it will be found more economical to procure the plants from some grower located in a more favourable region.

But it is important that plants be purchased of a reliable grower. The species of Eucalypts are so numerous, the seeds so small, and the different species so similar in the earliest stages of growth, that it is easy for honest confusion to arise in the mind of a grower who is not conscientiously careful. When to this is added unscrupulousness, the danger of not getting the species desired or called for is quite great. The Blue Gum seedlings are so well known that growers or buyers are seldom deceived in them. But it is not safe to buy any other species of any but a thoroughly reliable grower. Many nurserymen, if they have not the species called for, or are so ignorant as to be unacquainted with it, will substitute some entirely different species, thinking the purchaser will not know the difference, at least for some years.

SETTING IN THE FIELD.

When the seedlings are from 4 to 8 inches high, they are right for setting in the field. They usually attain this size when they are from four to six months old, but species vary considerably as to the time required to bring them to the given size. They bear transplanting better, and make a better start, after being set out at this stage, than they do when older and larger.

If the Eucalypts are being set primarily for shade, they may be set in single or double rows, 10 or 20 feet apart in the rows, along fences or irrigating ditches, or on each side of a road; or they may be scattered about the barnyard or the stockyard. But if they are being set for timber or for fuel, it is best to set them 8 to 16 feet apart each way in solid blocks. When set in this manner they grow straighter (thus making more serviceable timber), split more readily for fuel, and are in every way more useful than if they grow scattered about and exposed to distorting winds. Some species, like the Red Gum, that are slender and easily distorted by the wind the first year or two, will grow straighter if corn be planted among them. In regions where the sun is trying, the corn serves as a partial shade, as well as a wind-break. But, as stated before, Eucalypts thrive best in bright sunlight, and it is not well to permit the corn to encroach too closely upon the young plants.

SUBSEQUENT CARE.

The young plants should be given some water when set out, and in many cases the watering will need to be continued for some time. How long after setting the application of water should continue will depend upon the climate, and upon the weather that follows. In the coast region of California, where night and morning fogs are frequent, little artificial watering is necessary. Further inland, trees need to be watered for several weeks at least.

As most of the Eucalypts are quite delicate plants when small, they will need careful attention the first season. They should be cultivated and kept entirely free from weeds for from one to three years, according to the species and the condition of the soil. In many cases they will need some protection from animals. Rabbits and other rodents sometimes nibble off young plants. If these animals cannot be destroyed or excluded from the field, it will be necessary to protect each seedling from their ravages by means of a sheath of woven wire or other suitable material.

The great usefulness of the trees and the considerable length of time they are likely to remain where planted warrant the planter in giving the young plants all the attention they need until they become established. Any species should be given at least as much care as would be given a field of corn. The cost per acre for the care of the young seedlings need not be much greater than the cost of caring for a corn crop. To set young trees and then leave them to struggle with weeds, to suffer for want of water, or be injured by animals, is not economical. Eucalypts, like most trees, will endure quite unfavourable conditions when once established, but they need careful attention until they become thus fitted to cope with such conditions.

EUCALYPTS IN THE WEST INDIES.

In the lowlands of the West Indies, only a limited number of species of Eucalyptus are capable of withstanding the tropical conditions there existing. As might be expected, the ordinary Blue Gum (*E. globulus*) being a native of the temperate parts of Tasmania is quite unsuited for cultivation in these colonies, except at considerable elevation. The species enumerated below, as flourishing in the lowlands of Jamaica, British Guiana, Trinidad, Dominica and Antigua, deserve to be largely planted not only as shade or shelter trees, but also as a source of fuel. There are probably no trees that are likely to yield so large a supply of fuel within a short period. Further, it should be recognized that Eucalypts are capable of being maintained in an ornamental state, if continually cut down and coppiced. Such a method of treatment, coupled with subsequent judicious thinning of the shoots, would result in handsome bushy trees, in marked contrast to the tall, weedy growth usually associated with gum trees in the tropics.

JAMAICA.

In Jamaica, the planting of Eucalyptus trees has received very careful attention. In the Blue Mountains, 5,000 to 6,000 feet, the Blue Gum (*E. globulus*) thrives splendidly and yields good timber. It has also been planted as a hedge plant and regularly clipped. The most striking species grown at Cinchona is *E. ficifolia* with handsome crimson flowers.

In the report of the Director for the year ending March 31, 1894, it is stated that at the Hill Garden (Cinchona):—

'Six fair-sized trees of *Eucalyptus viminalis*, and *E. loxiphleba* were cut down and the trunks sawn into planks during the year. The planks have been used for rough outdoor work, such as bridging drains across walks, to test their durability.'

In the lowlands of Jamaica, about a dozen species of Eucalypts have been successfully established. In the years 1892 to 1894, the Botanical Department distributed, free of cost, several thousand plants for experimental trial in different districts of the island.

The Director (the Hon'ble W. Fawcett, B. Sc.) in his *Annual Report* for the year 1893-4 gives the following results of the experimental planting of Eucalypts along the sea-board and at moderate elevations in Jamaica:—

Dr. M. Grabham, Kingston.—Regarding the Eucalyptus plants supplied to the Penitentiary:—

E. microtheca has done the best; about nineteen plants have attained a large size, being 12 to 14 feet high.

E. robusta. There are six living plants but they do not look healthy. Large areas of the leaves are withered, apparently the result of excessive exposure.

E. rostrata. The only two plants are growing luxuriantly and exceed all the others in height,—16 feet.

E. citriodora. One plant has survived and has grown fairly well, but suffers in the same way as *E. robusta.*

E. sp.? (not *globulus*). One plant living and growing well, leaves loaded with essential oil.

E. microtheca and *E. rostrata* have succeeded well although, unfortunately, the essential oil in the leaves of the former is present only in small quantities.

I have recently been much interested, in reading Professor Leveran's work on malarial fever, to find that *E. rostrata* has been planted, 500 trees at a time, over large districts in Algeria which had hitherto been altogether uninhabitable on account of marsh fever. *E. globulus* had failed, being too delicate, and perishing rapidly in a marshy soil.

Mr. T. H. Cripps, Kingston.—All the plants are in a flourishing condition, several having attained a height of over 2 feet, and this under very unfavourable circumstances. (*E. robusta* and *E. microtheca.*)

Mr. R. B. Breakspear, Morant Bay, St. Thomas.—Most of the trees are from 2 feet to 2 feet 6 inches in height; one or two

have grown to 4 feet. (*E. microtheca, E. robusta* and *E. citriodora.*)

Mr. R. P. Simmonds, Port Maria.—Plants have all grown nicely and are from 2 to 5 feet in height. (*E. microtheca* and *E. robusta.*)

Mr. F. H. Barker, Retreat.—There are seven trees alive—about 4 feet 6 inches and others about 3 feet high. They do not appear to be very flourishing, although planted in moist swampy land. (*E. microtheca* and *E. robusta.*)

Mr. A. N. Sutherland, Moneague, St. Ann.—Many of the plants are now from 4 to 5 feet high and growing most luxuriantly, throwing out a nice lot of healthy, vigorous, lateral branches.

Mr. A. J. Hart, Green Island, Hanover.—The Eucalyptus plants are thriving well. (*E. microtheca* and *E. robusta.*)

Mr. A. C. Bancroft, Lucea.—The Eucalyptus plants sent me have done well and are growing apace, except some which were planted near the sea and have died from the effects of the salt. (*E. citriodora.*)

Mr. H. A. Vickers, Sav-la-Mar, Westmoreland.—Six of the trees are flourishing, the other six have died. One tree is 10 feet high, another 9 feet, and one is 7 feet The others are smaller, but are all coming on fairly well. Great attention is paid to these plants, and they are fenced with iron railings imported for the purpose. (*E. citriodora.*)

Mrs. Charley, Little London, Westmoreland.—Two-thirds of the trees supplied have grown into fine, healthy plants. (*E. microtheca* and *E. robusta.*)

Mr. R. K. Tomlinson, Lacovia, St. Elizabeth.—The plants have grown well, the majority being about 5 feet high, four having grown more rapidly, viz: *E. rostrata*, 11 feet high; *E. robusta*, 9 feet; *E. microtheca*, 8 feet; *E. citriodora*, 6 feet.

Mr. A. A. Green, Milk River, Clarendon.—The plants were put out on the wharf premises here; we have thirteen growing beautifully, some are 12 to 15 feet high and are very healthy. (*E. melliodora.*)

Dr. R. C. Gibb, Alley, Clarendon.—With the exception of three, all the plants are doing well. (*E. microtheca* and *E. robusta.*)

Mr. W. Charley, Spanish Town, St. Catherine.—The Eucalyptus trees have done remarkably well here; two trees measure, respectively, 10 feet 4 inches and 9 feet 4 inches in height, one of them being 6½ inches in circumference at its base. (*E. microtheca* and *E. robusta.*)

Mr. R. W. Butler, Linstead, St. Catherine.—I am sorry to say I have lost all the Eucalyptus plants, but fear it was more my fault than otherwise, as I kept them too long in the pots. (*E. rostrata.*)

Mr. G. C. Lindo, Old Harbour, St. Catherine.—All the trees are thriving. The majority are fully 8 feet high. (*E. microtheca* and *E. robusta.*)

Mr. D. H. Mendez, Old Harbour, St. Catherine.—I carefully planted twelve of them around my house and nine have grown. I also planted four at Lancewood Valley and three have grown. I gave away the remaining eight to friends and they report well of them. I notice that the plants do best in moist ground—around my swimming bath I planted four trees, as the place is continually wet, and they are doing better than the others, two of them being fully 7 feet high. *(E. microtheca* and *E. robusta.)*

The following further information is given by the Director in his *Annual Report* for the year 1894-5, of the experimental planting of Eucalypts in Jamaica :—

Col. Brown, Up-Park Camp.—The majority of the Eucalyptus plants seem to be well adapted to the purpose for which they were planted, with the exception of *E. corymbosa, E. tereticornis and E. crebra.* They are all thriving very well, but the three specimens above named do not appear to grow very fast. All are planted in the gully that takes the drainage from Camp. (*E. citriodora.*)

Mr. W. R. Thomas, Kingston.—The plants have done remarkably well. One is now 18 feet high and is about to blossom. I consider the growth extraordinary as compared with other trees planted at the same time. (*E. microtheca.*)

Mr. M. M. Alexander, Kingston.—The plants sent me last July, and the others, have grown at my residence, 'Mentmore,' Kingston, and are a perfect picture to look at.

Dr. G. J. Neish, Plantain Garden River.—The Eucalyptus plants put in at Hordley Hospital are not doing well, the hill-side being rocky and soil very shallow. About six appear to be growing fairly well. Four of the number which I planted about my house, in dry alluvial soil, are thriving and growing very tall and strong. (*E. rostrata.*)

Mrs. Hall, Manchioneal.—I regret to say that only three of the twenty-four lived. Those three are now about 5 feet high and quite strong. I attribute their death to my ignorance in the totally different system of cultivation needed in Jamaica to that in England. Now that I have learnt this, the last forty-eight, lately planted, are quite a success. (*E. microtheca.*)

Mr. W. C. Groves, Bath.—The *Eucalyptus robusta* plants are doing well.

Mr. R. P. Simmonds, Port Maria.—*Eucalyptus citriodora*, 20 feet, planted about six months before the others. *E. microtheca* 13 to 18 feet ; *E. robusta*, 8 to 14 feet high. All growing well.

Mr. M. Hart, Laughlands.—Of the twelve Eucalyptus plants supplied in 1894, seven are growing all strong and healthy, six are about 6 feet high and one quite 12 feet: this one may be accounted for by being planted in rather marshy soil. (*E. microtheca.*)

Mr. J. A. Bowen, Gray's Hill.—The Eucalyptus plants sent me in 1893 have done remarkably well. One has attained a height of 20 feet, another 12 feet, and the rest an average of 9 feet. These last are not in very favourable situations. I am

convinced that, with a little care at the outset, Eucalypts would flourish luxuriantly in the soil and climate of this district. (*E. robusta.*)

Mr. F. Edmond, Ocho Rios.—With regard to the Eucalyptus plants sent me in April, I am pleased to say that ten out of twelve are doing very well. (*E. microtheca.*)

Mr. G. E. Barrett, Pedro.—Three of the Eucalypts have reached a height of 12 to 15 feet. The others vary down to 4 feet. The larger leaved kinds grow best, the smaller leaved kinds seem more delicate.

Mr. D. M. Mendez, Old Harbour.—I received twenty-four plants. I gave away four, two of that number died. Five of those kept by me are not thriving as well as I should like, being planted in dry and arid spots, but the remainder are doing well and stand from 15 to 25 feet high. I find that they thrive better on moist ground. (*E. microtheca* and *E. robusta.*)

Dr. Neish, Old Harbour.—The Eucalyptus trees (*E. microtheca*) supplied to me by your Department have thriven beautifully. Only one out of the dozen plants failed to grow. The tallest measures 30 feet in height and the circumference of the trunk is 19 inches. Another measures 27 feet in height and 18½ inches in circumference. My finest tree is in blossom at the present moment. Their propagation as timber trees would, I think, prove most valuable. I do not know of any tree in Jamaica which has such rapid and erect growth.

Mr. G. C. Lindo, Old Harbour.—Every one has done well except one, 15 feet, which has died off. (*E. microtheca* and *E. robusta.*)

Mr. L. D. Baker, Port Antonio.—I have to report that all of our Eucalypts are planted on Bound Brook flat land, a portion of the Bog Estate adjoining the town of Port Antonio where the new railroad station is being built. This flat land is laid out in a plan as a town, with 50 feet streets, 30 feet of it being the driveway and 10 feet on each side of the driveway being sidewalks. We have planted these on the near side to the driveway, so that the trees will be between people walking on the sidewalk and the driveway. This land is alluvial deposit, ranging from 2 to 6 feet deep, inclined towards the sea. The plants seem to have taken well. We are planting a post near each one as a protection and as a support to it, and every care will be taken to make them grow successfully. We would like to have about 200 more, when it is convenient for you to give them to us. (*E. rostrata.*)

Mr. A. J. Hart, Sav-la-Mar.—I have to report that the Eucalyptus plants received in 1893 are thriving well, but those with the small tapering leaves (*E. microtheca*) grow much quicker here than the other kind (*E. robusta*); a couple of trees are about 25 feet in height.

Mr. R. H. Tomlinson, Lacovia.—The Eucalypts are growing well; four of them have made hardly any growth, being still 3 to 4 feet high and very spindling, owing to my planting them in shady places. The dimensions of the other nine

plants are as follows:—*E. robusta*—30 feet, 16 feet, 10 feet high; *E. citriodora*—13½ feet, 9½ feet, 10½ feet; *E. rostrata*—24 feet high; *E. microtheca*—14½ feet and 10 feet.

Dr. Manners, Bull Bay.—Of the Eucalyptus plants I got from you, twelve in number, nine have grown well and are now 20 feet high. You can almost see them grow. *(E. robusta* and *E. microtheca.)*

Parochial Board, Hanover.—The plants supplied in 1893 have continued to grow, some are now from 6 to 8 to 9 feet high, look healthy and will now do well.

BRITISH GUIANA.

The Acting-Superintendent of the Botanic Gardens, British Guiana, writes:—

The following species of Eucalyptus are under cultivation at these Gardens, the Military Cemetery at Georgetown, and at the Gardens at New Amsterdam, Berbice:—

Eucalyptus alba (?),	*E. resinifera*,
E. citriodora,	*E. robusta*,
E. corymbosa,	*E. tereticornis*,
E. gomphocephala,	*E. cornuta*,
E. longifolia,	*E. hemiphloia*,
E. rostrata,	*E. melliodora*,
E. paniculata,	*E. rudis*,
	E. siderophloia.

The first ten of these have a better growth than the others and seem best suited for cultivation under the climatic conditions of British Guiana.

TRINIDAD.

The Superintendent, Royal Botanic Gardens, Trinidad, writes:—

The only species of Eucalyptus which really thrives with us, in Trinidad, is *E. tereticornis*, of which we have trees with trunks 4 feet in diameter, ripening seed regularly.

E. citriodora grows fairly well, but does not last many years.

E. globulus absolutely refuses to thrive and will not live for more than a year. All the species are particularly tender in their young stages, and require to be raised under glass.

ST. VINCENT.

The Curator of the Botanic Station at St. Vincent writes:—

The following is a list of the species of Eucalyptus under cultivation at the Botanic Station:—

Eucalyptus crebra, *E. tesselaris*, *E. tereticornis* and *E. citriodora*.

The first named is especially vigorous in growth, the second and third less so, and the last named is rather sickly.

Some years ago, plants of *E. globulus* were planted out in fairly swampy land at Calliaqua, but, either through lack of attention or the unfavourable situation, they all died.

BARBADOS.

The Superintendent of the Botanic Station writes as follows :—

There are at Dodds two Eucalyptus trees, viz :—*E. citriodora* and *E. crebra*, both of which are growing nicely, and are now about between 50 and 60 feet high. *E. citriodora* is now in flower but *E. crebra* has not yet flowered. The only other Eucalypt I have tried to grow at Dodds was *E. globulus.* This grew fairly well until it reached a height of about from 15 to 20 feet, when it stopped growing, gradually faded and eventually died. This has been, I understand, the experience of every one who has tried to grow *E. globulus* in the lowlands in the West Indies.

DOMINICA.

The Curator of the Botanic Station, Dominica, writes :—

The following species of Eucalyptus are grown successfully in the Botanic Gardens here :—

E. citriodora, E. tereticornis, E. tesselaris, E. corymbosa and *E. crebra. Eucalyptus globulus* has been grown, but it only remains alive for two or three years. Other species, such as *E. microcorys*, promise to do well, and *E. capitellata* and *E. junctata* (?) are now being raised in the nurseries for trial. The first five kinds mentioned thrive well in poor and shallow soils, but *E. citriodora* and *E. tereticornis* are the quickest growers.

At the St. Aroment estate another species grows very well, but the name is not known to Dr. Nicholls.

The leaves of *E. citriodora* and *E. tereticornis* are in request for treatment of fever. An infusion is made of the leaves and drunk by the patient.

On lime estates, where there is a scarcity of timber, it would be wise to plant up portions of the poor land with such species as *E. citriodora* and *E. tereticornis*, and other fast growing kinds for the purpose of supplying fuel. The trees would be ready for cutting in five or six years. As they ratoon well, it is probable that they would bear cutting every four or five years. Native trees felled for fuel are not ready to be cut again for ten years. Some enterprising planter might make a trial of growing Eucalyptus trees for furnishing fire-wood.

ANTIGUA.

The Acting-Curator of the Botanic Station, Antigua, writes :—

The species of Eucalyptus under cultivation at the Botanic Station and elsewhere in Antigua are *E. amygdalina, E. citriodora, E. cornuta, E. gomphocephala, E. robusta* and *E. rostrata.*

The places where the plants occur, in addition to the Botanic Station, are Clare Hall, Skerrett's, Bendal's and Gray's Hill.

At this station it has been found in the past that, although seeds of *E. cordata* and *E. calophylla* germinated, the seedlings did not easily bear transplanting.

In the year 1890, sixteen species of Eucalyptus were planted at Clare Hall. Of these, eleven damped off, one was destroyed, while the remainder had not been planted sufficiently long to be reported on. Recently I found strong, healthy specimens of *E. amygdalina*, *E citriodora* and *E. robusta* there.

I am indebted to Mr. A. Spooner for the information that the 'Iron Bark' (*E. leucoxylon*), 'Messmate,' (*E. obliqua*) and 'Red Gum' (*E. rostrata*) are regarded in Australia as being exceedingly useful, drought-resisting timber trees. The bark of *E. obliqua* supplies shingles.

ST. KITT'S.

The Curator of the Botanic Station, St. Kitt's writes :—

At the Botanic Station there are *Eucalyptus resinifera*, *E. obliqua*, *E. citriodora* and *E. robusta*.

E. globulus attained a height of 6 feet at the cemetery when it was destroyed by a hurricane, but the plant was not sturdy and evidently out of its element.

E. tereticornis grows splendidly in Trinidad. All these kinds, except *E. globulus*, thrive at low elevations (100 to 300 feet) in well drained situations, and withstand long periods of drought. I have never seen them growing in swampy land. The plants are raised from seed which should be protected from ants and under glass, as the seedlings are very delicate in the early stages. No use is made of any part of the plant here.

EUCALYPTS SUITABLE FOR TROPICAL CONDITIONS IN THE WEST INDIES.

The following particulars are furnished of the several species of *Eucalyptus* that have been found suitable for planting in the West Indies from sea-level up to elevations of about 1,000 feet :—

E. acmenoides, Schauer. 'White Mahogany.' Tropics and beyond. The wood is heavy, strong, durable, of a light colour, and has been found good for palings, rails, flooring boards, battens and many other purposes of house-carpentry.

E. amygdalina, La Billardière. 'Peppermint Tree.' In Australia, the largest of the Eucalypts. Flourishes best near the coast and at moderate elevations in well-watered mountain regions. The leaves furnish a large amount of Eucalyptus oil, containing, as they do, over 3 per cent, of volatile oil. The timber is not very valuable.

E. capitellata, Smith. 'Stringy Bark tree.' Timber used principally for fence rails, shingles and rough building purposes. Can be raised in wet, sandy land.

E. citriodora, Hook. 'Lemon scented Eucalyptus.' Succeeds in India and in some parts of the West Indies; particularly adapted for a tropical jungle climate. Tropics and beyond. Supplies a useful timber.

E. corymbosa, Smith. 'Bloodwood tree.' On dry ridges and hills or in open forest ground, ascending to considerable mountain elevations. Tropics and beyond. A dark, reddish

wood, soft when fresh, but very hard when dry; very durable underground, and therefore extensively used for fence posts, rails, railway sleepers, and rough building purposes. Fence posts from this tree showed hardly any decay after 40 years, but it is too much traversed by kino to serve for sawn timber.

E. cornuta, La Billardière. 'Yate tree.' A large tree, of rapid growth. Prefers a humid soil. Well adapted to tropical climates. The wood is used for work requiring toughness, hardness and elasticity. An effective low wind-break.

E. crebra, F. v. M. 'Narrow-leaved Iron Bark tree.' Chiefly on scrubby ridges, and near the sea-shore. Tropics and beyond. Wood reddish, hard, heavy, elastic and durable; much used in the construction of bridges and for railway sleepers, also for wagons, piles, fence posts. The wood bears an enormous strain.

E. gomphocephala, D. C. The 'Tooart' of south-west Australia. Thrives best in limestone soil. Attains a height of 120 feet. The wood is tough, heavy and rigid: it shrinks but little, does not split during the process of seasoning and is remarkably free from defects. One of the strongest woods known.

E. hemiphloia, F. v. M. 'Grey Box.' Grows well near the coast and in hot, dry, inland valleys. Timber famous for its hardness and toughness, used for railway sleepers, telegraph poles, etc. A good fuel wood.

E. longifolia, Link. 'Woolly-butt'. Thrives near the coast. The timber is durable, but not so strong as that of many other Eucalypts.

E. melliodora, A. Cunningham. 'Yellow Box.' Wood used in wheel-wright's work, etc., also forms excellent fuel. Flowers much sought by bees.

E. microcorys, F. v. M. 'Wangee.' In forest country or on arid or even sandy hills, along the coast side of the ranges, descending to their base. Tropics and beyond. Wood very durable, also durable underground; used for naves, felloes and spokes, also for lasting railway cross-ties. Suitable for culture in humid tracts.

E. microtheca, F. v. M. Occupies hilly as well as flat ground and even dry, sandy places, widely distributed through the interior of Australia; it is one of the largest trees in the desert tracts, and is suited to country subject to floods. Tropics and beyond. Wood brown, sometimes very dark, hard, heavy, and elastic; it is prettily marked, hence used for cabinet work, but more particularly for piles, bridges and railway sleepers.

E. obliqua, L'Héritier. 'Messmate.' Grows mostly in mountainous countries and content with poor dry soil. Wood used for rough building purposes. Supplies a large amount of wood in a short time.

E. paniculata, Smith. 'Red Iron Bark.' Grows well near the coast. The wood is hard and durable, especially suited for railway sleepers, and, generally, for use underground.

E. planchoniana, F. v. M. It grows on arid, somewhat sandy or more particularly rocky ridges near Moreton Bay. Beyond tropics. Timber sound, heavy, hard and durable, well adapted for sawing, but not easy to split.

E. platyphylla, F. v. M. Available for open, exposed localities. Tropics and beyond. Timber curly and durable.

E. resinifera, Smith. 'Red Mahogany.' Suited for warm, moist situations. One of the most valuable hardwood timbers known; it resists damp and the attacks of white ants.

E. robusta, Smith. 'Swamp Mahogany.' The tree thrives well in low, sour, swampy land near the sea-coast, where other Eucalypts look sickly. The wood is useful for posts, ties, etc.

E. rostrata, Schlecht. 'Red Gum tree.' Throughout nearly the whole of Australia, at low elevations; nearly always found on moist ground with a clayey subsoil. It will thrive in ground periodically inundated for a considerable time, and even in slightly saline places. Tropics and beyond.

E. rudis. If supplied with water, the tree will thrive in a variety of climates. Timber not so valuable as that of some other Eucalypts.

E. saligna, Smith. In rich soil along banks of streams, in woods, also on the outskirts of forests. Beyond tropics. The wood employed for rails will last a life time. Is of excellent quality, and largely used for building purposes.

E. siderophloia, Benth. 'White Iron Bark tree.' Beyond tropics. This furnishes one of the strongest and most durable timbers of New South Wales, used with great advantage for railway sleepers and for many building purposes. It is likewise highly appreciated by wheel-wrights, especially for spokes, also well adapted for tool handles and various implements. Its extreme hardness renders this wood difficult to work.

E. tereticornis, Smith. 'Flooded Gum tree.' Never very far from littoral regions, occupying generally humid flats or growing round swamps and lakes or along water courses, never on saline ground, or salt water streams; becomes stunted when growing in rocky exposed localities. Tropics and beyond. Will thrive on undrained ground. The timber is esteemed for the naves and felloes of wheels. For telegraph poles and railway sleepers, it is inferior to some of the iron bark trees, lasting a shorter time.

E. tesselaris, F. v. M. 'Moreton Bay Ash.' Furnishes a brown, rather elastic wood, not very hard, easily worked, of great strength and durability: particularly used for staves and flooring.

THE TREATMENT OF ORCHARD SOILS.

At the Agricultural Conference held in 1901 at Barbados, the Hon'ble Francis Watts read a paper on 'The Treatment of Soils in Orchard Cultivation in the Tropics' (*West Indian Bulletin*, Vol. II., p. 96), that is, the proper treatment of soil under such crops as lime, cacao, orange, nutmeg, etc.

Mr. Watts suggested that, possibly, the best kind of treatment to adopt was to leave the soil between the trees untilled, the only cultivation being the periodical cutting back of the rank grass and weeds with a cutlass.

The advantages claimed by Mr. Watts for this method were that the soil would be kept in a good state of tilth, by the dying of the roots of the weeds and the action of earthworms; and that the weeds, spreading over the surface, would conserve moisture and add steadily to the humus of the soil; while the economy of the method. especially on hill slopes, was obvious.

Mr. Watts recommended that it would be desirable to try to substitute leguminous plants, as far as possible, for other weeds and so add to the nitrogen of the soil.

In the discussion that followed, divergence of opinion appeared as to whether thorough surface cultivation or the method suggested by Mr. Watts was the better system.

This question, of the best treatment for orchard soils, has also been a debated one in other countries besides the West Indies.

In England, experiments have been carried out at the Duke of Bedford's experiment farm at Woburn to test the effects of grass and weeds around apple trees in orchards. The results were published in the *First Report of the Woburn Experiment Fruit Farm* in 1897.

In these experiments the principal points tested were:—

1. The size of the leaf.
2. The length of new wood formed.
3. The number of new shoots on the trees.
4. The value of the crop of fruit.

The measurements of leaf were obtained by taking the sixth leaf from the ends of six shoots of each tree and determining the length and breadth. Shoots were selected which were disposed at about equal intervals round the tree. The measurements were made in August of 1896 and were repeated in September. No alteration in the size of the leaf had occurred in the interval. The leaf area was taken to be three-quarters of the length multiplied by the breadth. Whether this gave the exact area. or not. does not matter. as the figures were only used for purposes of comparison.

In measuring the length of new wood formed during the year, any growth of less than 1 c.m. (0·4 inch) was neglected and, as the growth of the main and lateral branches of the trees was entered separately. the number of the latter, which

is one of the features utilized, was obtained at the same time as the measurements.

To obtain the value of the fruit, the crop from each plot was divided into three grades, according to size, and the fruits in each grade were counted, weighed and measured. The three lots were then valued.

It was found that there was considerable agreement between the results obtained by the various measurements.

In the experiments to determine the effect of grass round trees, a mixture of grasses, recommended for orchards on heavy land was sown in the spring of 1895. The grass did not come up till late in the year, yet in the second year after planting it had produced a reduction of 35 per cent. in the size of the leaf with the dwarfs, and 41 per cent. with the standards; while the reduction of growth in wood had amounted to no less than 87 per cent. with the dwarfs, and 74 per cent. with the standards. With the dwarfs there was also a reduction of the crop of fruit, amounting to 71 per cent. in weight and 82 per cent. in value.

The plots with other weeds in place of grasses showed a reduction in growth of wood of 43 per cent. (grass 74 per cent.).

The leaves of the grass-grown trees were much lighter in colour than those of the other trees and were shed earlier.

The reason suggested why grass is so much more injurious than other weeds, is that most of the grasses were perennial and so were in operation throughout the year, while most of the other weeds were annuals and so were active for only a part of the year.

The report goes on to state that:—

'The ways in which grass militates against the welfare of trees planted in it are several. It, no doubt, absorbs in part the dressing of manure which would otherwise benefit the tree, although in our experiments the plant food is not permanently removed from the soil, as the grass is cut and left on the plots, and, during the past seasons, the manures have, owing to the drought, had no effect on the results: it prevents the hoeing of the ground, and the consequent aeration of the soil; and, lastly, it promotes evaporation from the soil, both directly from the leaves of the weeds, and indirectly by preventing tillage, which fills up the cracks through which the moisture of the soil escapes.

'It is to the last mentioned action that we are inclined to attribute the greater part of the ill effects of grass during the past two seasons. Some comparative experiments of Greaves, extending over fourteen years, showed that, in a sandy ground, the average annual evaporation from the soil when turfed was 18·1 inches, whereas from the exposed soil it was only 4·2 inches, or less than one-quarter as much; and in a dry season, such as those of the last two years, a similar increase in the evaporation would probably reduce the water in the soil below the limit at which trees begin to suffer or wilt. If this be correct, the effect of grass in a wetter season would be less marked than we have found it.

'The effect of the hardening of the soil, which grass promotes through absence of tillage, has been measured separately in No. 18, and the results here show an average loss in leaf-size of 17 per cent. This value is probably lower than it should be since, up to the present, the weeds in the plot have been removed by the hoe instead of being pulled as they should have been, and the loosened ground made firm afterwards.

'It is possible that the trees planted in grass may (as appears to be happening in other cases) recover, after a few years, part of their lost vigour, and it is possible, also, that the sowing of grass round older and well-established trees might have but a small effect on them: but, as regards newly-planted trees, the present results can leave no doubt but that grass round the roots is, with the exception of total general neglect, the most disastrous method of treatment which can be adopted, at any rate in a dry season, and, even if it lead to no other ill effects, must result in a retardation of growth equivalent to several years of the trees' lifetime, with a corresponding loss of time and money.'

In connexion with the importance attributed to the loss of water from the soil by transpiration from the leaves of the grass, it should be noticed that, in the paper above referred to, Mr. Watts recommends his method of leaving the soil untilled chiefly for such places 'as have an abundant rainfall' and states that 'how far it would be successful in a dry district I cannot say.'

The effect that a cover crop in orchards has on the conservation of soil moisture is well shown by a series of experiments carried out by Mr. F. T. Shutt, M.A., the Chemist of the Experimental Farms in the Dominion of Canada, and published in the *Experimental Farms Reports* for 1902. The experiments were started in 1901 and continued through 1902.

The first series of experiments was designed to investigate the effect on soil moisture-content of (*a*) cultivation throughout the year, (*b*) cropping with clover till the end of May or beginning of June, followed by ploughing and cultivation till the latter part of July and then re-sowing with clover, and (*c*) the growing of clover throughout the season.

The use of clover, in these experiments, is of interest in connexion with Mr. Watts' suggestion as to the advantage of using leguminous crops in orchards. The results of the experiments of 1902 are thus given:—

'*First Series.*—Three adjoining plots, each 40 by 120 feet in the apple orchard.

'Plot 1.—Disc-harrowed in spring, and cultivated throughout the season at intervals of a few days to a fortnight as occasion required.

'Plot 2.—The clover from the previous year's sowing was cut June 4, but allowed to grow until June 9, when it was ploughed under. The land was then disc-harrowed and kept fallow by constant harrowings and cultivations (June 12, 16, 25 and July 8). It was re-sown to clover on July 21, but the growth was exceedingly sparse, and the ground became, before

the close of the season, virtually covered with purslane. with very little clover showing.

'Plot 3—The plot was allowed to remain in clover (sown in 1901) throughout the season, the crop being cut from time to time, but not taken away. The dates of cutting were as follows: June 4, 26, July 22, August 27.'

TABLE I.

First Series.—Percentages of water in soils, (*a*) cultivated throughout the season, (*b*) under cover crop and cultivated, and (*c*) in clover throughout the season.

Dates of Collection.		Rainfall in inches.	Plot 1. Cultivated throughout season.	Plot 2. Clover ploughed under, June 9, cultivated to July 21, then re-sown with clover.	Plot 3. In clover throughout season.
1902.					
April	5	1·11	14·77	15·55	15·96
,,	19	0·71	10·09	12·96	12·93
May	3	2·13	13·36	16·03	14·60
,,	17	0·52	12·79	10·02	11·89
,,	31	1·10	11·46	10·80	12·00
June	14	2·14	12·98	12·36	13·16
,,	28	2·01	9·86	13·13	11·79
July	12	0·41	11·30	11·07	9·07
,,	26	3·55	15·44	13·46	13·56
August	8	0·24	11·66	12·91	9·23
,,	23	1·53	13·76	13·72	10·91
September	6	0·49	11·83	7·14	6·99
,,	20	0·37	7·85	7·98	5·43
October	4	1·31	13·33	13·09	10·66
,,	18	1·51	14·45	13·56	14·68
,,	31	1·45	14·57	14·44	14·30
November	15	1·06	14·63	15·48	15·53

It is stated that the season of 1902 was a very unfavourable one for the growth of clover. There was consequently not the same draught upon the soil moisture due to the growth of the 'cover' crop in 1902 as in 1901. In fact the soil conditions of the three plots more or less approximated in certain essential particulars. Nevertheless, the results point to the same conclusion as did those of 1901, namely, that cultivation conserves soil moisture, while the growth of a cover crop dissipates it.

The second series of experiments was designed to determine the effect of a permanent grass sod on soil moisture in orchards:—

'*Second Series.*—Two adjoining plots in the plum orchard

'Plot I.—Cultivated throughout the season of 1902. The dates of cultivation are as follows: May 8, June 11, July 9, July 29, and August 4. The plot had been ploughed in the spring of 1901 and kept cultivated during the season.

'Plot II.—In permanent (2-year old) sod throughout the season. The grass was cut and allowed to remain that it might act as mulch. The mowings were on June 2, June 30, and August 11.'

It will be seen, from the table given below, that these experiments gave most decisive results, which are thus stated in the report:—

'These two soils started out with practically the same moisture-content (*see* April 19), but, as the season advanced and the grass grew, the demand on the soil moisture of Plot 2 became greater and greater. This began to be evident soon after May 1. By May 15, there was 50 per cent. more moisture in the soil (to a depth of 14 inches) of the cultivated plot than in the soil covered with sod. At the end of May this difference had increased to almost 100 per cent.; in other words, there was nearly twice as much moisture in the cultivated soil as in that under sod, due partly to the conserving action of cultivation on the one plot (No. 1), and partly to loss of moisture from transpiration of the foliage and greater loss due to capillary action in the soil in the other (No. 2) plot.

'Throughout the whole growing season, most marked differences in the moisture-content of the soils of these two plots are to be observed—and always in the same direction. If during the two weeks previous to the collection of the samples there had been an ample rainfall—as, for instance, for the periods ending June 14 and 28, and July 26—the moisture-content of the plots did not differ to the same extent that they did after periods of comparative drought. The last column of Table II furnishes data in this connexion of a most decisive character, pointing especially to the heavy call on the moisture of the orchard soil by sod at a time when the trees are most in need of it. Towards the close of the season, when vegetative growth has ceased, and there is a liberal rainfall, the soils approximated more and more in their moisture-content, and the experiment closed, as it had begun, with soils equally moist or practically so.'

TABLE II.

Second Series.—Percentages of water in soils (*a*) cultivated, and (*b*) in sod.

Dates of Collection.	Rainfall in inches.	Plot 1. Cultivated throughout season.	Plot 2. In Sod (2nd. Year).	Excess of moisture in the Cultivated Plot per acre.	
1902.				Ton.	lb.
April 5 ...	1·11	...	...	...	
„ 19 ...	0·71	15·31	15·88	16	29
May 3 ...	2·13	18·37	16·26	58	1,332
„ 17 ...	0·52	15·37	10·75	117	25
„ 31 ...	1·10	17·30	9·81	192	211
June 14 ...	2·14	16·62	10·49	157	253
„ 28 ...	2·01	18·19	13·69	121	1,836
July 12 ...	0·41	16·07	7·24	217	1,136
„ 26 ...	3·55	14·32	11·80	64	285
August 8 ...	0·24	14·65	6·47	196	58
„ 23 ..	1·53	15·83	8·96	171	1,020
September 6 ...	0·49	13·61	8·33	126	1,818
„ 20 ...	0·37	9.24	4·77	98	1,875
October 4 ...	1·31	12·29	9·17	75	980
„ 18 ...	1·51	14·77	15·12	...	
„ 31 ..	1·45	15·94	15·57	9	1,946
November 15 ...	1·06	16·52	17·29	...	

In summing up the results of the English and Canadian experiments one or two points stand out clearly.

In the first place, it is evident that the effect of a permanent grass sod around orchard trees is injurious. This is due chiefly to the steady drain on the water-content of the soil by the grass throughout the year.

The effect of a cover crop, which is only operative during a part of the year, is also, in dry situations, injurious to the trees, though not to such an extent as the permanent sod. In places where there is an abundance of moisture while the cover crop is on, its deleterious influence will be less and the use of a cover may, for other reasons, be advantageous. This is a point on which no general rule can be laid down; the best treatment must vary in each locality.

That neither permanent sod nor temporary cover crop conserves moisture, as suggested, is quite evident.

In both reports, it is noticed that the injurious effects are much more marked with young than with mature trees.

KOLA NUTS.

The plants yielding kola nuts are natives of tropical Africa. One or more species have become established in the West Indies, and they are commonly cultivated throughout these colonies. A useful summary appears in the *Kew Bulletin*, 1890, pp. 253-60. The most valuable kola nuts are claimed to be those with two cotyledons only. These are said to be in keen demand in West Africa, as well as, for the purpose of manufacture, in Europe and the United States of America. The question has lately been raised whether the trees, hitherto under cultivation in the West Indies, yield nuts of the best quality; and, if not, whether it would be possible to obtain the plants of the true sorts from West Africa.

A general review of the various kinds of kola nuts was contributed by Mr. E. M. Holmes, F.L.S., in an interesting article that appeared in the *Pharmaceutical Journal*, June 23, 1900 :—

The kola nuts in commerce have for some time puzzled botanists and pharmacognosists on account of their variation in colour and form. Evidence has not, hitherto, been forthcoming to show whether these seeds are the produce of different species, or of varieties of one species, and the literature on the subject has, to a certain extent, been overlooked. Dr. K. Schumann of Berlin, who has recently investigated the matter, and has written a monograph on the genus *Cola*, has divided that genus, which now comprises thirty species, into subgenera. He includes the kola nut in his sub-genus *Autocola*, which is characterized by the stamens, or rather sessile half-

anthers being arranged in two rows, one above the other, and not in a single row as in the majority of species.

Dr. Schumann describes the fruit of *Cola acuminata* as having a fleshy yellow pericarp, with an odour resembling that of a Maréchal Niel Rose, and containing four or five large seeds. The seeds have a white testa, which becomes brown when the fruit dehisces, and they become exposed to the light. The embryo consists of four cotelydons, of a 'carmine' red colour, which, when separated, present a triangular, or, externally, a convex form. These remarks apply to the kola nut brought to Germany from the Cameroons.

Examination of specimens of the kola plants in the Herbarium of the Botanical Museum at Berlin showed that one plant from Ashanti, collected by Cummins, and another from Sierra Leone, collected by Afzelius, differed from the true *Cola acuminata* in having the stigmas broad, obtuse, and closely pressed to the ovary. Specimens of the kola nut with two cotyledons obtained direct from Togoland, and of the tree yielding it, proved to Dr. Schumann that the kola nut of commerce, having two cotyledons, is the product of the tree having obtuse appressed stigmas, and not of *C. acuminata*, which has pointed, free, curved stigmas. This new species he has named *Cola vera*. It also has seeds of a carmine red colour when fresh. But the two seeds germinate in a totally different manner. In the one, *C. acuminata*, the four cotyledons spread open and the plumule grows up in the centre ; in the other, *C. vera*, the two cotyledons remain closed, and the plumule arises outside them.

These two are not the only species yielding edible seeds. The *C. lepidota*, Schm. which belongs to the same sub-genus, having the anthers in a single row only, but seeds with two cotyledons, and another species used by the Bali people, are also eaten. How much these different seeds vary in the amount of the caffeine and theobromine they contain has not yet been ascertained, but the seeds of *Cola vera* are the most highly prized. The large leaf in which they are wrapped is identified as that of *Cola cordifolia*.

The two different kola seeds above described were noticed as long ago as 1860. C. Barter, in his account of the plants found during the Niger Expedition, given in the *Journal of the Linnean Society*, Vol. IV., p. 19, states that there are two kinds of kola nuts, one with four cotyledons, called 'Fatak' by the Foulahs, and the other with two cotyledons, called 'Ganja', by the same people. The latter was said to come from the Ashanti country, but he had not seen the tree. The species with four cotyledons he had seen at Fernando Po, and in many parts of the lower Niger, abundant at Onitsha, occurring also at Prince's Island, and apparently common along the coast, the flowers being variable in colour, cream-coloured, greenish yellow and pale red. The seeds appeared to be carried in about equal quantities into the interior, but the one with two cotyledons (Ganja), in the Nupe country, is worth about 100 cowries, whilst the other (Fatak) averages about 80 only. The value of cowrie, at Rabba, was 2,500 for the dollar of 4*s*. 4*d*.

According to the *Jamaica Bulletin*, 1900, p. 154, Dr. P. Preuss, Director of the Botanic Gardens, in the German Cameroons, West Africa, was of opinion that the kola trees, that came under his observation during his visit to Jamaica, were *Cola vera* and yielded nuts that were much finer than any he had seen in Africa.

So far Dr. Preuss' opinion has not been confirmed by a critical examination of Jamaica specimens at Kew.

In the meantime efforts are being made to obtain seeds or plants of *Cola vera* direct from West Africa.

Imperial Commissioner of Agriculture—to Colonial Office.

Barbados,
April 3, 1903.

Sir,

I have the honour to enclose, herewith, an extract from the *Pharmaceutical Journal* referring to the difference existing in kola nuts found in West Africa, and pointing out that certain varieties with two large cotyledons and prized as the best are not derived from *Cola acuminata* but from a distinct species—*C. vera*.

2. It is believed that nearly all the kola plants existing in the West Indies, originally obtained from West Africa, are *Cola acuminata*. The seeds in this species usually have several cotyledons, and on that account they are said to be not so valuable, commercially, as those with two cotyledons.

3. As it is desirable that kola trees yielding the best kind of nuts should be introduced for cultivation into the West Indies, I would suggest that the kind assistance of the Director of the Royal Gardens, Kew, be invited to obtain from West Africa for this Department seeds or plants of any species or varieties of *Cola* yielding nuts with two large cotyledons.

4. I may add that what is regarded as *Cola acuminata* thrives well in many parts of the West Indies and the nuts are a regular article of export. The price obtained for them is, however, very low, and it has been represented to me that if it were possible to produce larger nuts, with only two cotyledons, the price might be slightly better.

I have, etc.,

(Sgd.) D. MORRIS,
Commissioner of Agriculture
for the West Indies.

[*Enclosure.*]

Extract from the *Pharmaceutical Journal* of
February 28, 1903.

VARIETIES OF KOLA SEEDS.

Considerable attention has lately been paid to the botanical sources of the several varieties of kola seeds that are

known. Schumann has pointed out that the kola seeds, with two large cotyledons, such as are met with in commerce and prized as the best, are not derived from *Cola acuminata*, but from a distinct species which is named *C. vera*. Warburg has now examined specimens of kola trees from Ashanti and from Kpandu. In the former case he finds slight differences in the floral envelopes and in the andraecium, which indicate that it is possibly a new species or variety of *C. vera*. As the andraecium is lobed, he proposes the name *C. sublobata* for it. The Kpandu kola tree possesses a stellate andraecium borne upon a slender stalk, and for this plant the name *C. astrophora* is put forward. Both of these trees yield seeds with two large cotyledons. (*Tropenpflanzer*, through *Apot. Ztg.*, 18, 35.)

The Colonial Office—to the Imperial Commissioner of Agriculture for the West Indies.

Downing Street,
May 26, 1903.

Sir,

I am directed by Mr. Secretary Chamberlain to acknowledge the receipt of your letter of the 3rd. ultimo (S.S. 1212) relative to the proposed introduction into the West Indian Islands of certain kinds of kola, and to transmit to you, for your information, the accompanying copy of a letter from the Director of the Royal Gardens, Kew, enclosing a memorandum on the subject.

2. The Governor of Sierra Leone is being requested to forward to Kew parcels of kola seeds produced in that colony, in order that, if possible, plants may be raised in due course and transmitted to the West Indies as suggested by Sir W. Thiselton-Dyer.

I am, etc.,

(Sgd.) H. BERTRAM COX.

[*Enclosure.*]

Director, Royal Gardens, Kew—to the Colonial Office.

Royal Botanic Gardens,
Kew, May 18, 1903.

Sir,

I have the honour to acknowledge the receipt of your letter of May 12 (14758/03), transmitting a copy of a letter from the Imperial Commissioner of Agriculture for the West Indies on the subject of the introduction into those islands of a more valuable kind of kola than is at present cultivated there.

2. I enclose a memorandum on the technical aspect of the question, from which it will be seen that the discrimination of the several kinds of kola has been attended with considerable difficulty. This arises from the well-known fact that very

marked differences in the properties of distinct but closely allied plants may be accompanied by very slight recognizable characters.

3. It seems, however, probable, that the kola seeds with two cotyledons produced in Sierra Leone are the desired product. I submit, therefore, that the Government of that colony should be moved to transmit to Kew, two or more successive parcels of these seeds, to be packed with proper precautions by the Curator of the Botanic Station. If this can be successfully done, plants will be raised in due course and transmitted to the West Indies.

4. The Curators of the several West African Stations will be asked to collect full specimens of the various kola trees, accessible to them, for further study at Kew.

I am, etc.,

(Sgd.) W. T. THISELTON-DYER.

MEMORANDUM.

The existence of two kinds of kola nuts, viz: one with two and the other with four cotyledons, in West Africa, has been known for many years, as well as the fact that the kind with two cotyledons was more valued in the native markets. They were considered, until lately, as seed variations of one species, viz: *Cola acuminata*, R.Br. In 1893, however, Professor Heckel pointed out that they were derived from distinct species, the one with two cotyledons which he called 'le Kola vrai' or 'Kola du Soudan' from *C. acuminata*, R.Br., the other from a new species, *Cola Ballayi*, Cornu, the 'Kola du Gabun.' K. Schumann, in his monograph of the African Sterculiaceae, and in an article on the origin of the kola nuts in the *Tropenpflanzer*, IV (1900), confirmed Heckel's statement so far as the origin of the kola nuts with two and four cotyledons from two distinct species was concerned, but came to the conclusion that R. Brown's *Cola acuminata*, which was based on Palisot de Beauvais' *Sterculia acuminata* from the Niger Delta, was the inferior species with four cotyledons. He reduced therefore *Cola Ballayi* to a variety of *C. acuminata* (the 'small' kola), and proposed the name *C. vera* for the 'true' or 'large' kola.

Quite recently, in the *Tropenpflanzer* for 1902, Warburg published a paper on the Togo kola nut, in which he suggested that Schumann's *Cola vera* comprised two distinct species: the Sierra Leone kola, for which he retains the name *Cola vera*, and the Ashanti kola which he describes as *Cola sublobata*. To this he adds another new species from Togo, *Cola astrophora*, which is also stated to yield good 'nuts.' The differences adduced refer, however, almost exclusively to the male flowers, and there is, so far, no evidence whether and how the seeds ('nuts') of *C. vera*, *C sublobata*, and *C. astrophora* can be distinguished. As the differences, particularly in so far as the first two species are concerned, are moreover very slight and possibly within the range of individual variation, I consider it,

for the present, more expedient for practical purposes to treat the Sierra Leone and Ashanti kola as forms of *Cola vera* in contra-distinction from the inferior article, *C. acuminata*, which possibly also comprises several distinct forms.

As to the discrepancy between Heckel's and Schumann's explanation of the type of *Cola acuminata*, namely, Beauvais' *Sterculia acuminata*, I wish to remark that neither author seems to have seen it, and both relied on Beauvais' figures of *Sterculia acuminata*; and it seems to me that Beauvais figured a flowering branch and detached male and female flowers of the 'small' kola and added a figure of a seed of the 'large' or 'true' kola, such as he might have bought in the market.

Nearly all our kola specimens from the West Indies seem to be *Cola acuminata*. I say 'seem' because they all bear stamens only, and in this state are very difficult to recognize. There are, however, at the Museum, some fruits named *Cola acuminata* from the West Indies, which belong evidently to a species near *C. pachycarpa*, the seeds of which are used for adulterating the true kola.

The reason why the kola nuts with four cotyledons (*C. acuminata*) are less prized than those with two (*C. vera*) is in the proportion of caffeine and theobromine they contain; the respective figures being, according to Heckel, 1·05 per cent., and 2·35 per cent.

'Large' kola seeds (*C. vera*) might no doubt be obtained from Sierra Leone which has an old reputation for good kola nuts, or from the Gold Coast; but I would remark that the mere fact of the seeds having two cotyledons is not a sufficient character to distinguish the seeds of *Cola vera* from those of certain other species of kola which are useless, e.g., of *C. pachycarpa.*

(Sgd.) OTTO STAPF.

Jamaica Kola Nuts in Commerce.

In answer to inquiries on the subject of kola nuts and the prospects for this product, the following letters have recently been published:—

Messrs. Gillespie Bros. & Co., London—to the Director of Public Gardens & Plantations, Jamaica.

With reference to the low range of prices now current for this article, we have made inquiries from what we believe to be well informed sources, and we understand that the chief cause of the decline is the fact that France (formerly a large buyer here) now imports direct from Africa in big parcels. In the second place, many of the advertising manufacturers (cocoa, drinks, etc.) both here and in the United States of America are not pushing the article as they were a few years ago; and it does not seem that kola has caught on in either country to the same extent as in France. Our brokers think there will always be a moderate demand at about 2*d.* to 3*d.* per ℔., but former prices are a thing of the past.

Messrs. Gillespie Bros. & Co., New York—to Director, Public Gardens, Jamaica.

There is a regular demand for the dried in small quantities at from 4 cents to 6 cents per lb. The green should not be shipped, and the dried not in lots of more than from 1 to 2 tons, because for some years Africa and the other West Indies have been sending all that was required in this market. As a matter of fact, the knowledge that unlimited supplies are procurable has had the effect of cheapening the article, and there is no likelihood of a return to the probable rates of four or five years ago. There is no duty on the article in the United States.

Messrs. E. A. De Pass & Co., London—to Director, Public Gardens, Jamaica.

The demand for kola nuts in London is a fair one, and the present value is about 3½d. to 4d. per lb., for good, sound nuts, but the great majority of those received from Jamaica are mouldy, and in that condition are almost valueless. It is true that, some years ago, kola fetched a considerably higher price, but, since then, the supplies have materially increased. The principal point, however, to impress upon shippers from Jamaica, is that nuts should be prepared in such a way that they may arrive here absolutely sound.

In a review of West Indian Products at the Drug and Spice sales in London, Mr. J. R. Jackson, A.L.S., writes in the *Agricultural News*, Vol. II., p. 149, as follows:—

Kola was represented at the first sale of the month by eleven bags of fair, bold, rather dull West Indian nuts, which realized 4*d*., while mouldy West Indian fetched 1¼*d*.; good, natural, small and medium were taken out at 5½*d*. In connexion with West Indian kola it may be stated that the English trade journals have noted some facts on the low range of prices from the *Bulletin* of the Department of Agriculture, Jamaica, and draw special attention to the necessity of Jamaica shippers packing the seeds in such a way that they should arrive in a perfectly sound condition. Good, sound West Indian seeds are at present very scarce in the London market, and such would probably meet with a ready sale at 5*d*. per lb.; indeed, a bag of good, bright, natural West Indian realized this price at the sale on March 19.

BAY OIL AND BAY RUM.

(Continued.)

In the current volume of the *West Indian Bulletin* (pp. 119-28) a preliminary account was given of the Bay oil and Bay rum industries in the West Indies.

It is desirable to supplement this by information that was not accessible at the time, but has since been communicated on the subject.

The following further particulars respecting the 'bois d' Inde' tree of Dominica, referred to on page 126, is taken from the Report, of the Superintendent, on the Royal Botanic Gardens at Trinidad for the year 1896 :—

Bois d' Inde citron. The nomenclature of the tree, whose common name is given above, has been a matter of correspondence between the Department and the Royal Gardens, Kew, during the past year.

It would appear that the plant is correctly identified with Poiret's *Myrtus citrifolia*, but the absence of full botanical specimens for critical examination has not allowed any definite conclusion to be arrived at, and the plant has been placed, for the present, with the *Pimenta acris* of Wright and Arnott, and will probably remain there, unless specific differences of character can be clearly distinguished on further examination. The attention of this Department was directed to the plant by the authorities of the Royal Gardens, Kew, who were making inquiries as to the progress of a plant sent to these gardens by them some years ago. The plant in question is thriving well and is some 18 feet in height, but has not as yet produced flowers.

Referring to Mr. R. J. Lechmere Guppy for information, I learnt that a tree had for many years existed in his father's garden at San Fernando, and that, on the hill above, there were numerous young plants growing freely. On making a close search in the Departmental Herbarium, I found specimens which had been collected, at the same place, by the late Dr. Finley over thirty years ago—labelled *Pimenta acris*, Wright and Arnott, var. *Myrcia pimentoides*, De Candolle, Guppy's Garden.

Learning the tree was yet there, I obtained permission from the present owner of the property, and obtained specimens of the leaves, but, unfortunately, no good flowers or seeds were obtainable. I obtained flowers at a later period of the year, but not in sufficient quantity to be of service for the purpose of critical examination. I procured, however, some leaves with the view of ascertaining whether it were possible to obtain from them an essential oil having the odour of citron. A small quantity of a very clear, light yellow oil was obtained on distillation, which possessed marked differences of character from that obtained from leaves of *Pimenta acris*, Wright and Arnott. A tube of this was sent to Messrs. Schimmel and Co., who have reported on the oil, as new, in the following terms :—

'The oil, obtained from the leaves of a *Pimenta* not yet classified, has a light yellow colour, and strong lemon-like odour; its specific gravity is 0·882 at 25 C.; its optical rotation is 0·37 at 27 C. in a 100mm. tube.

'The distinct odour of citron induced us to ascertain the presence of this body by chemical re-action, and we easily obtained Citryl-bi-napho-cinchoninic acid, proving the presence of Citral in this oil.'

The specimen sent to Messrs. Schimmel was a very small one, but, having obtained a larger supply of leaves from Dominica (where the tree appears to be indigenous), through the good offices of Mr. Jones of the Botanic Station, I have obtained a larger return of the oil, and it has been placed in suitable hands for obtaining a thorough chemical examination.

Mr. Jones writes me that the plant is common in Dominica, and is frequently mixed by the collectors with the leaves of the true *Pimenta acris* when collecting that kind for distillation—but that the citron odour destroys the value of the bay oil and therefore the leaves of the 'bois d' Inde citron' were always carefully excluded.

The same subject is dealt with by the Curator of the Botanic Station at Dominica in his report for the year 1896:—

Inquiries were addressed to the station by the Superintendent of the Royal Botanic Gardens, Trinidad, respecting the tree known in Dominica under the name of 'bois d'Inde citron.' Mr. Hart had previously obtained a small sample of oil from the leaves of a tree growing in Trinidad, which, on examination, was pronounced by experts as new to the market. Wishing to continue the experiment, Mr. Hart applied for a barrel of leaves from Dominica. This was forwarded, and the oil obtained is now being examined.

The oil yielded by the leaves of the 'bois d'Inde citron' or 'bois d'Inde citronelle' has been exported from Dominica in the past, but it was found that it could not compete with the oil obtained from the lemon grass (*Andropogon*), the latter being produced much more cheaply. Still, should a thorough chemical examination reveal new properties, and the oil become in demand, it will, no doubt, again be exported.

The tree known as 'bois d'Inde citron' is distinct in size, shape, and odour of its leaves from the Bay oil tree, *Pimenta acris*, known as 'bois d'Inde,' but, as collectors of Bay leaves are apt to gather both kinds, great care is taken by the distillers of Bay oil to exclude the leaves of the 'bois d'Inde citron,' otherwise the Bay oil suffers deterioration.

Persons engaged in the Bay oil industry profess to recognize a third variety of *Pimenta*. Efforts are being made to obtain botanical specimens of this and other trees for determination.

The Administrator of Dominica (the Hon'ble H. Hesketh Bell, C.M.G.), has been good enough to furnish the following later information respecting the exportation of Bay leaves from that island:—

The Administrator, Dominica—to the Imperial Commissioner of Agriculture.

Dominica, June 4, 1903.

Sir,

I have the honour to acknowledge the receipt of your letter No. D. 1962 of the 20th. ultimo, covering a very interesting pamphlet on the subject of Bay oil and Bay rum.

2. I find that, up to about four years ago, there was a considerable export of bay leaves from this island; so important, indeed, was the traffic, that in 1898 the trade was worth £1,372. Since then, however, the business seems to have decreased, and the demand for leaves has fallen to such a point that, last year, the amount exported was only worth £490.

3. I was glad to learn, recently, that the trade is now showing signs of revival, and that several considerable orders for bay leaves have been received here lately.

4. I am told by a gentleman, who has always been interested in the traffic, that the cause of the decrease in the demand for Dominica bay leaves is due to the fact that, when Porto Rico became attached to the United States, large quantities of leaves were obtained from that island, and, being free of import duty, crowded our produce out of the market. It is, however, now asserted, that the Porto Rico leaves are inferior to those obtainable here, and that the Dominica bay leaf trade will probably soon resume its former proportions.

5. I am informed that the best variety of bay tree is fairly common in Dominica and that it exists in large numbers in our forests. The Dominicans are well aware of the value of bay leaves, and there is, I think, no danger of the trees being wantonly destroyed.

6. I will refer this matter to the Agricultural Instructor with the request that he will, when visiting the various districts of the island, make special inquiries on the subject of bay trees.

I have, etc.,

(Sgd.) H. HESKETH BELL,
Administrator.

The Imperial Commissioner of Agriculture—to the Administrator, Dominica.

Barbados, June 22, 1903.

Sir,

I have the honour to acknowledge the receipt of your letter No. 28/151, dated the 4th. instant, and I have to thank you for the very interesting information contained in it relating to the occurrence of bay trees and the export of bay leaves from Dominica.

2. I quite agree that the subject is one that deserves to be more fully investigated, and trust that the Agricultural Instructor will take up the work and furnish a really useful summary of information in regard to the distribution of the

trees in the several districts and the methods usually employed for collecting and harvesting the leaves. Also, what steps, if any, are desirable for encouraging the growth of the trees and maintaining them in a productive condition.

I have, etc.,

(Sgd.) D. MORRIS,
Commissioner of Agriculture
for the West Indies.

The following particulars, supplied by Mr. Oliver Nugent, respecting the occurrence of Bay trees at Barbuda have been communicated by his Excellency Sir Gerald Strickland, K.C.M.G., the Governor of the Leeward Islands :—

There are two kinds of Bay trees, closely allied, found in Barbuda. They are, no doubt, *Pimenta acris* and the 'bois d' Inde citron', of Dominica, referred to in the pamphlet.

The number of trees of both kinds in this island is very limited, and does not seem to increase, no doubt from the thickness of the scrub.

Mr. Harper, who has the right of distilling Bay oil from these trees, has only succeeded, so far, in securing 8 gallons from the whole crop of leaves.

Bay oil and Bay rum, made from the oil, seem to be of considerable value and in demand in English and American markets. I noticed that the cost of 3 half-pints is put down at 16*s.* 8*d.*, which would be equal to over £6 per gallon.

I am of opinion that these trees prefer a volcanic soil. They grow well on the south side of Antigua but not on the north side, which, like Barbuda, is of limestone formation.

BAY TREES IN PORTO RICO.

The Bay tree of Porto Rico is described in the Economic Plants of Porto Rico by O. F. Cook and G. N. Collins* under *Amomis caryophyllata*—Bayberry tree, Bay rum tree, Wild Cinnamon, and Ausu. The local names are variously reported by Bello, Krug, Stahl, and Sintenis as 'ausu,' 'auzu,' 'guayavita,' 'limoncillo,' 'malagueta,' and 'pimenta malagueta.' A Myrtaceous tree, from the dried leaves of which is obtained, by distillation with water, an essential oil called 'Bay oil' or 'Oil of bay,' the most important ingredient of Bay rum. Only $1\frac{1}{2}$ pints of oil is said to be required for the medication of 100 gallons of rum. The latter should be of good quality and strength. If below 18 or 19 proof it will not properly incorporate with the oil. Large quantities of dried leaves of this species are imported from the West Indies, notably from the island of Dominica. They are generally put up into bales of about 200lb. in weight. It is not known that any leaves have been shipped from Porto Rico, but in 1895, 95 gallons of Bay oil, valued at $1,390, and 12,544 gallons of

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* Contributions from the United States National Herbarium, Vol. VIII, part 2, 1903 (pp. 63-296.)

Bay rum, valued at $6,414, were exported. The trees occur in all parts of the island and are said to be abundant in some districts on the south side. The industry is worthy of investigation as one probably capable of profitable expansion, although not likely to become of more than minor and local importance.

In the fresh condition; the leaves of this tree have the taste and odour of lemon, whence the propriety of the name 'limoncillo' or 'little lemon.' Although more common in Porto Rico as a shrub, this species is said to grow to a height of 35 to 40 feet (11 or 12 metres), and to attain a diameter of 1 foot (30 centimetres) or more; the wood is light-coloured, mottled, very hard and heavy. Captain Hansard reports that the tree is cultivated at Maunabo and at other points for the sake of the leaves.

There are probably several other Myrtaceous trees which share with this the name 'pimento,' but the present is probably that which Hill and others have supposed to be allspice. (Stahl, IV, 72.)

A tree 45 to 50 feet (14 to 16 metres) high, the straight, rather long trunk, 15 to 24 inches (35 to 55 centimetres) in diameter. Furnishes a moderately hard and heavy wood, fine and compact in texture. The sap-wood is very light red with darker lines, while the heart is brownish-red, brown, or on account of the knots, almost black. It is susceptible of a very high polish. Specific gravity, 0·909. It is one of the best and most valued woods of these countries, very strong and durable, suitable for carpenter's and cabinet work, and it is exported to some extent. The bark is rough and ash-coloured, and peels after the manner of the sycamore. (Grosourdy, II: 398.)

This is an interesting account of the Bay oil tree of Porto Rico. It is, however, not complete. In the first place, the scientific name applied to it, viz. *Amomis caryophyllata*, Krug. is reduced in the supplement to *Index Kewensis* (p. 24) to *Pimenta acris*, Kostel. and should therefore bring it into line with the true Bay oil tree of other parts of the West Indies. On the other hand, if in the Porto Rico trees, generally, 'the leaves have the taste and odour of lemon, whence the propriety of the name "lemoncillo" or "little lemon," this would indicate that they are identical with the 'bois d'Inde citron' of Dominica. The leaves of the latter, as already shown, are always excluded in the preparation of Bay oil at Dominica; otherwise the produce suffers serious deterioration. Also, according to the analysis of Messrs. Schimmel & Co., the oil obtained from 'bois d'Inde citron' has been proved to contain *Citral*, indicating a marked difference between it and true Bay oil. The information now available would appear to confirm what is stated above by the Administrator of Dominica, that the leaves of the Bay tree of Porto Rico, in so far as they are the produce of 'bois d'Inde citron,' are inferior to those of Dominica. It is probable that the true Bay tree (*Pimenta acris*) may be found at Porto Rico; but if the leaves of all the trees met with have 'the taste and odour of lemon' they are

useless for the preparation of the best qualities of Bay oil, and therefore, also, of Bay rum. It would be interesting to learn the character of the trees reported by Captain Hansard as 'cultivated at Maunabo and other points for the sake of the leaves.' These may be true Bay oil trees.

It is hoped that it may soon be possible to make a critical examination of the leaves and flowers of 'bois d'Inde citron' and compare them botanically with those of the true Bay oil trees (*Pimenta acris*).

If, as probable, the tree known in Dominica as 'bois d'Inde citron' is not specifically distinct from true *Pimenta acris*, it may very appropriately be known as *P. acris*, var. *citrifolia*. It is to be remembered that, at Montserrat at least, three Bay oil trees are known in that island, viz.—White, Red and Black Cinnamon.

As mentioned by Sir William Thiselton-Dyer in his letter to the Colonial Office (p. 185), in the case of Kola nuts, the discrimination of the several kinds of Bay oil trees may be attended with considerable difficulty, owing to the well-known fact that very marked differences in the properties of distinct but closely allied plants may be accompanied by very slight recognizable characters.

In concluding this brief summary of what is known as Bay oil trees in the West Indies, we shall be correct in assuming that the best kind of leaf for the manufacture of Bay oil is derived from the typical or true Bay tree (*Pimenta acris*). This is said to be known in Dominica as 'bois d'Inde' and is probably identical with the White Cinnamon of Montserrat. Amongst the several varieties of Bay trees known in the British and Foreign West Indian Islands, there is one with the leaves possessing the taste and odour of lemon. This is known in Dominica as 'bois d'Inde citron.' The oil obtained from the leaves of this has a distinct citron flavour and, if mixed with true Bay oil, is said to destroy its value in commerce. It is important therefore that, as is already so carefully done at Dominica, the leaves with a lemon scent should be excluded from those intended to be used in the preparation of Bay oil. The tree with the lemon-scented leaves, the 'bois d'Inde citron, of Dominica, we suggest, might be known as *Pimenta acris*, var. *citrifolia*.

COTTON CULTIVATION IN THE UNITED STATES.

THE following useful summary of information in respect of cotton cultivation in the United States is taken from one of the recently published additional volumes of the *Times* edition of the *Encyclopædia Britannica*, (Vol. XXV., pp. 221-3):—

The cotton plant has undergone a remarkable development since its introduction in the southern States. The cultivated cottons of to-day differ much from the original form of *Gossypium herbaceum*, which produced seed-cotton, whose lint was only 25 per cent. of its weight, and had a staple only 20 to 30 mm. long. Under the influence of the climate, soils and cultivation of these States, the proportion of lint has been greatly increased, reaching as high as 36 and even 40 per cent. in some varieties; while the length of the staple has increased correspondingly, reaching in a few varieties a length of 50 or even 60 mm. In only a few varieties, however, have we obtained this great increase in both percentage of lint and length of staple. Usually, when the length and fineness of the staple are increased, the weight is reduced, and *vice versa*. In cases where both length of fibre and weight have been increased, the cotton runs down again very rapidly, first, usually, in the weight produced. Cotton is a plant which supports easily and responds quickly to differences of environment, soil, climate, treatment and manures, and can thus be greatly modified in form and habit in a few successive generations. The flowers are open; the pollen is produced in great abundance, and is borne upon the slightest breeze. The stigmas are well above the anthers, so that cross-fertilization is easy and common. Seeds from the earlier maturing bolls produce plants yielding a longer lint than those from the later-ripened bolls on the same plant. Some varieties produce a long silky fibre when grown in rich moist soil, but soon lose these qualities when grown on the poorer hill lands. A variety which has been grown for years in the northern belt of the cotton region will mature its whole crop at the same time,

while the same variety grown for a few years in the southern part of the belt will continue to ripen through several weeks, though the total yield will be no greater. With this natural tendency to vary, and with all these forces to impel the plant to change its form or habit, varieties are multiplied indefinitely, even without the help of the cultivator. Of true botanical varieties, however, there are few, if any; while the agricultural varieties, so called, are almost innumerable. The result of this natural tendency of the plant is that the names of agricultural varieties are in great confusion, and there is a good deal of humbugging connected with the business of selling cotton seed for planting. The natural tendency of this variation is always back towards its original form. Unusual fruitfulness always results in loss of vitality, and the original form, yielding a small crop, always has the greater vitality, and so a greater prepotency in cross-fertilization. As a result of this law, constant care in the selection of seed is essential in order even to keep an improved variety up to its present standard. Only the seed from the finest typical plants should be saved and used. The neglect of these principles leads surely to degeneration of the so-called improved variety. In this way planters are often disappointed with the results secured from high-priced seed of new varieties, for which great claims are made by their originators, and large prices paid. The old method of saving seed for planting was to take a sufficient number of bushels just as they came from the gin. The new method of selecting the best plants only of the typical form is resulting in the steady improvement of the cotton plant. If it is intelligently pursued by a large number of planters for another century, or even a score or two of years, it will certainly result in the still further improvement of this wonderful plant. The great desire, of course, is to secure a cotton plant which will yield a maximum amount of fibre of the longest and finest staple. It is believed by experts that cotton will be improved steadily until this end is reached.

The culture of cotton must be a clean one. It is not necessarily deep culture, and during the growing season the cultivation is preferably very shallow. The result of this is a great destruction of the humus of the soil, and great leaching and washing, especially in the light loams of the hill country. The main object, therefore, of the cotton-planter is to prevent erosion. Wherever the planters have failed to guard their fields by hillside ploughing and terracing, these have been extensively denuded of soil, rendering them barren, and devastating other fields lying at a lower level, which are covered. The hillsides have to be gradually terraced with the plough upon almost an exact level. On the better farms this is done with a spirit level or compass from time to time, and hillside ditches put in at the proper places. In the moist bottom-lands along the rivers it is the custom to throw the soil up in high beds with the plough, and then to cultivate them deep. This is the more common method of drainage, but it is an expensive one, as it has to be renewed every few years. More intelligent planters drain their bottoms with underground or open drains.

In the case of small plantations the difficulties of adjusting a right-of-way for outlet ditches have interfered seriously with this plan. Many planters question the wisdom of deep-breaking or subsoiling. There is no question that a deep soil is better for the cotton plant; but the expense of obtaining it, the risk of injuring the soil through leaching, and the danger of bringing poor soil to the surface have led many planters to oppose this plan. Sandy soils are made thereby too dry and leachy, and it is a questionable proceeding to turn the heavy clays up upon the top. Planters are, as a result, divided in opinion as to the wisdom of subsoiling. Nothing definite can be said with regard to a rotation of crops upon the cotton plantation. Planters appreciate generally the value of broad-leaved and narrow-leaved plants and root crops, but there is an absence of exact knowledge, with the result that their practices are very varied. It is believed that the rotation must differ with every variety of soil, with the result that each planter has his own habit in this respect, and little can be said in general. A more careful study of the physical as well as the chemical properties of a soil must precede intelligent experimentation in rotation. This knowledge is still lacking with regard to most of the cotton soils. The only uniform practice is to let the fields 'rest' when they have become exhausted. Nature then restores them very rapidly. The exhaustion of the soil under cotton culture is chiefly due to the loss of humus, and nature soon puts this back in the excellent climate of the cotton-growing country. Fields considered utterly used up and allowed to 'rest' for years, when cultivated again, have produced better than those which had been under a more or less thoughtful rotation. In spite of the clean culture, good crops of cotton have been grown on some soils in the south for more than forty successive years. The fibre takes almost nothing from the land, and where the seeds are restored to the soil in some form, even without other fertilizers, the exhaustion of the soil is very slow. If the burning up of humus and the leaching of the soil could be prevented, there is no reason why a cotton soil should not produce good crops continuously for an indefinite time. Bedding up land previous to planting is almost universal. The bed forms a warm seed-bed in the cool weather of the early spring and holds the manure, which is drilled in, usually, to better advantage. The plants are generally left 2 or 3 inches above the middle of the row, which in 4-foot rows gives a slope of 1 inch to the foot, causing the plough to lean from the plants in cultivating, and thus to cut fewer roots. The plants are usually cut out with a hoe from 8 to 14 inches apart. It seems to make little difference exactly what distance they are, so they are not wider apart on average land than 1 foot. On rich bottom-land they should be thinner. The seed is dropped from a planter, five or six seeds in a single line, at regular intervals, 10 to 12 inches apart. A narrow deep furrow is usually run immediately in advance of the planter, to break up the soil under the seed. The only time the hoe is used is to thin out the cotton in the row; all the rest of the cultivation is by various forms of ploughs and so-called cultivators. The question of deep and shallow culture has been much discussed

among planters without any conclusion, applicable to all soils, being reached. All grass and weeds must be kept down, and the crust must be broken after every rain, but these seem to be the only principles upon which all agree. The most effective tool against the weeds is a broad, sharp 'sweep' as it is called, which takes everything it meets, while going shallower than most ploughs. Harrows and cultivators are used where there are few weeds, and the mulching process is the one desired. The date of cotton-planting runs from March 1 to June 1, according to situation. Planting commences early in March in Southern Texas, and the first bloom will appear about May 15. Planting may be done as late as April 15, in the Piedmont region of North Carolina, and continue as late as the end of May. The first blooms will appear in this region about July 15. Picking may commence on July 10 in Southern Texas, and continue late into the winter or until the rare frost kills the plants. It may not begin until September 10 in Piedmont, North Carolina. It is a peculiarity of the cotton plant to lose a great many of its blooms and bolls. When the weather is not favourable at the fruiting stage, the otherwise hardy cotton plant displays its great weakness in this way. It sheds its forms, as the buds are called, its blooms, and even its half-grown bolls in great numbers. It has frequently been noted that even well fertilized plants upon good soil will mature only 15 or 20 per cent. of the bolls put on. No means is known so far for preventing this great waste. Even experts are at an entire loss to form a correct idea of the cause or to apply any effective remedy.

Cotton picking is at once the most difficult and most expensive operation in cotton production. It is paid for at the rate of from 45 to 50 cents per cwt. of seed-cotton. This is light work, and is effectually performed by women and even children, as well as by men ; but it is tedious and requires care. The picking season will average 100 days. It is difficult to get the hands to work until the cotton is fully opened, and it is hard to induce them to pick over 100lb. a day, though some expert hands are found in every cotton plantation who can pick twice as much. The loss resulting from careless work is very serious. The cotton falls out easily or is dropped. The careless gathering of dead leaves and twigs, and the soiling of the cotton by earth or by the natural colouring matter from the bolls, injure the quality. It has been commonly thought that the production of cotton in the south is limited by the amount that can be picked, but this limit is evidently still very remote. The negro population of the towns and villages of the cotton country is usually available for a considerable share in cotton picking. There is in the cotton States a rural population of over 7,000,000, more or less occupied in cotton growing, and capable, at the low average of 100lb. a day, of picking daily nearly 500,000 bales. It is evident, therefore, that if this number could work through the whole season of 100 days, they could pick three or four times as much cotton as the largest crop ever made.

THE ORIGIN AND DISTRIBUTION OF SEA ISLAND COTTON.

The following description of the origin and distribution of Sea Island cotton by Dr. Walter H. Evans is taken from *Bulletin* No. 33 of the office of Experiment Stations, United States Department of Agriculture :—*

The determination of the species of cotton grown in the United States, presents some peculiar difficulties. The authorities differ widely regarding the specific origin of the short staple or Upland cotton, while more nearly agreeing on that of the Sea Island cotton. The latter is generally considered as having originated from *Gossypium barbadense*, a technical description of which is given below.

G. barbadense Linn. was originally described as having leaves three-lobed, entire. A more amplified, compiled description is as follows : Shrubby perennial, 6 to 8 feet high, but in cultivation herbaceous and annual or biennial, 3 to 4 feet high, glabrous, dotted with more or less prominent black glands. Stem erect, terete, branching. Branches graceful, spreading sub-pyramidal, somewhat angular, ascending, at length recurving. Leaves alternate, petiolate, as long as the petioles, rotund, ovate, subcordate, three- to five-lobed, sometimes with some of the lower and upper leaves entire, cordate, ovate, acuminate ; lobes ovate, ovate-lanceolate, acute or acuminate, channelled above, sinus sub-rotund ;. above, green, lighter on the veins, glabrous ; beneath, pale green and glabrous, three- to five-veined, the mid-vein and sometimes one or both pairs of lateral veins bearing a dark-green gland near their bases. Stipules erect or spreading, curved, lanceolate-acuminate, entire or somewhat laciniate. Peduncles equal to, or shorter than, the petiole, erect, elongating after flowering, rather thick, angled, sometimes bearing a large oval gland below the involucre. Involucre three-partite, erect, segments spreading at top, many-veined, broadly cordate-ovate, exceeding half the length of the corolla, nine to eleven divided at top, divisions lanceolate, acuminate. Calyx much shorter than the involucre, bracts cup-shaped, slightly five-toothed or entire. Corolla longer than the bracts. Petals open, but not widely expanding after flowering, broadly obovate, obtuse, crenate or undulate margin, yellow or sulphur coloured, with a purple spot on the claw, all becoming purplish in age. Stamens about half the length of the corolla, the tube naked below, anther-bearing above. Style equalling or exceeding the stamens, three- to five-partite. Ovary ovate, acute, glandular, three- , rarely four-, to five-celled. Capsule a little longer than the persistent involucre, oval, acuminate, green, shining, three-, rarely four-, to five-valved. Valves oblong or ovate-oblong, acuminate, the points widely spreading. Seed six to nine in each cell, obovate, narrowed at base, black. Fibre white, three to four, or more, times the length of the seed, silky, easily separable from the seed. Cotyledons yellowish, glandular, punctate.

**The Cotton Plant*: Its History, Botany, Chemistry, Culture, Enemies and uses. Washington : Government Printing Office, 1896.

Species which have been considered identical with *G. barbadense*, and to which the above description will apply, are *G. frutescens* Lasteyr., *G. fuscum* Roxb., *G. glabrum* Lam., *G. jamaicense* Macfad., *G. javanicum* Blume, *G. maritimum* Todaro, *G. nigrum* Hamilton, *G. oligospermum* Macfad., *G. perenne* Blanco, *G. peruvianum* Cav., *G. punctatum* Schum. and Thonn., *G racemosum* Poir., *G. religiosum* Parlatore, *G. vitifolium* Roxb., and perhaps others.

This species is indigenous to the Lesser Antilles and probably to San Salvador, the Bahamas, Barbados, Guadaloupe, and other islands between 12° and 26° north latitude. By cultivation it has been extended throughout the West Indies, the maritime coast of the southern States, Central America, Porto Rico, Jamaica, etc., southern Spain, Algeria, the islands and coast of western tropical Africa, Egypt, Island of Bourbon, East Indies, Queensland, New South Wales, etc. It may be cultivated in any region adapted to the olive and near the sea, the principal requisite being a hot and humid atmosphere, but the results of acclimatization indicate that the humid atmosphere is not entirely necessary, if irrigation be employed, as this species is undoubtedly grown extensively in Egypt. As a rule, the quality of the staple increases with the proximity to the sea, but there are exceptions to this rule, as that grown in Jamaica and some other islands is of rather low grade, while the best fibre is produced along the shores of Georgia and Carolina. According to Royle[1], 'the quality is influenced not only by temperature, but by the balance between the amount of moisture taken up by the roots and that given off by the leaves, as well as by the varied processes of culture and choice of varieties suited to each particular locality.' This observation applies to all kinds of cotton, and not to the Sea Island alone. Some authors question the American origin of this species, and one, Maxwell T. Masters,[2] claims that it is of Central African origin; but the weight of testimony is against him, and in all probability this was the species grown on the island of San Salvador, at the time of the landing of Colombus, and by him carried to Spain. Some authors claim to recognize a difference between *G. barbadense* and *G. maritimum*; but whether it is more than a cultural variety is very difficult to determine, and for our purpose they are considered as botanically identical, while they may be commercially distinct.

There is a well marked form of the Sea Island cotton to which Todaro gave the varietal name of *G. polycarpum*, to which the Bamia variety of Egyptian cotton is usually referred. It is principally characterized by numerous flowers springing from a single axil, and an erect, slightly branching habit, hence giving a large yield per acre. On poor soil it soon degenerates to an ordinary form of Sea Island. This is considered by Sir J. D. Hooker[3] as a well marked seminal sport, with a fastigiate habit, from some kind of Egyptian

1. Cultivation of Cotton in India.
2. Journal Linnaean Society, xix, p. 213.
3. Flora of British India.

cotton, the bulk of which belongs to the See Island form of *G. barbadense.* In one of the Kew reports[4] the idea that Bamia is a hybrid between ochro and cotton is shown to be incorrect. The cultivation of Bamia in Egypt is said to require more irrigation than that of the ordinary kinds.

The yield of lint from Sea Island cotton is less than that from any other kind grown in this country, but, on account of the length and quality of the fibre, it is adapted to uses to which the other kinds are not suited, and its high market value compensates for the small yield.

VARIETIES OF SEA ISLAND COTTON.

The following interesting description of certain improved varieties of Sea Island cotton and their treatment is taken from *Bulletin* No. 25 of the Bureau of Plant Industry, United States Department of Agriculture, 1903 :—

SEA ISLAND VARIETIES.

SEABROOK.

This variety was originated ten or twelve years ago by E. L. Rivers, James Island, S.C. Its selection and improvement have been carried on since that time by the present owner, Mr. F. P. Seabrook, of James Island, who has given the most careful attention to the fixing of the desired qualities, the aim being the production of a prolific bearer of medium quality, with a large proportion of lint to seed. The method of selection employed by Mr. Seabrook, which is similar to that of most of the Sea Island planters, is as follows : Several of the best plants in his field are selected and marked. Each of these is picked by itself, the seed cotton weighed, and the lint weighed after ginning to determine the ginning average. The staple is examined critically as to length, fineness, strength, uniformity, and softness. Finally, the best plant is selected and the others discarded. The seed from this single stalk is planted by itself, one seed in a hill, and usually produces about 500 plants. The seed from these plants is used to sow a field of about 5 acres, from which the general crop is planted the fourth year. A new plant is chosen from the select field each year, so that the process of improvement is continuous.

Plant of compact habit, prolific, and resistant to disease. Bolls of good size, long and pointed, three-locked, opening well for Sea Island. Lint 2 inches long. Percentage of lint about 28 to 29.

The seed of this variety distributed was grown by Mr. F. P. Seabrook, James Island, S.C., in the season of 1901.

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4. Kew Report, 1887, p. 26.

RIVERS.

The Rivers Sea Island cotton, which is immune to the serious malady known as 'wilt' or 'black-root,' was produced as a result of special breeding experiments conducted by Mr. E. L. Rivers, of James Island, S.C., in conjunction with the Department of Agriculture. It is highly recommended for cultivation in the Sea Island districts of Georgia and Florida on all soils infected with wilt. A special circular is distributed with the Rivers cotton, and this variety is referred to here simply to show the general plan of the entire cotton distribution for the season. A careful description of the variety and of the experiments leading to its production appears in *Bulletin* No. 27, Division of Vegetable Physiology and Pathology of the United States Department of Agriculture, by Mr. W. A. Orton.

METHODS OF CULTIVATION AND GINNING.

The Seabrook selection of Sea Island cotton is adapted to light, sandy land of good fertility. It is planted in rows 5 feet apart, with a distance of from 18 to 20 inches between the plants in the row. Greater care must be given to the cultivation of Sea Island than is usually given to Upland cotton. The land should be thoroughly prepared and well fertilized. A suitable rotation with corn, cow peas, pea nuts, or other crops should be practised in order to avoid the exhaustion of the soil produced by many successive cotton crops. Cultivation should be very frequent. In the Sea Islands the cotton is cultivated, on an average, once a week until August. Here the cotton is grown on high beds and the soil is drawn up around the plants in cultivation. This method is not recommended for Georgia and Florida, however, where the more economical method of level culture will probably pay the best.

Particular care is necessary in picking and handling Sea Island cotton in order to obtain the highest price. Sea Island cotton requires to be picked often—every week or ten days—in order to avoid staining by the weather. All trash, bits of bolls, immature and diseased or yellow locks must be picked out by hand. The seed-cotton should be spread on a platform and exposed to the sun for several hours to dry before storing. It must be ginned on a roller gin and be packed carefully in bags without high pressure.

HOW TO GROW PURE SEED OF GOOD QUALITY.

It is a well-known fact that varieties of cotton become mixed and impure unless special care is taken to prevent crossing with other varieties. If growers receiving seed of any of the varieties sent with this circular desire to grow the same variety another year, precaution should be taken to plant the seed in an isolated patch, situated as far as possible from any other varieties. It should be at least a quarter of a mile from any other cotton and preferably in a field surrounded by a forest, particularly on the side nearest to other cotton fields. Before any seed is gathered for planting all plants which are not true to the type of the variety should be carefully weeded out.

If it is desired to keep the variety up to its full productiveness and better adapt it to local conditions, the planter may easily accomplish this by following a simple and inexpensive method of selection. Before beginning the picking, go over the patch carefully and select and mark with a white cloth the best plants; that is, those most productive, earliest in ripening, and having the largest, best formed, and most numerous bolls. Care should also be exercised to select plants that are true to the type of the variety. Before each picking send a careful man over the patch to pick the seed from the selected plants. Preserve such seed separately, gin it separately to avoid mixing, and use this to plant the crop the next year. If this simple method of selection is carried out each year, the yield will doubtless be greatly increased, and as much or more added to the crop than would result from special fertilization or cultivation, though these factors should by no means be neglected. The importance of careful seed selection is seldom fully recognized, and growers are urged to give this factor of cotton culture more careful attention.

HERBERT J. WEBBER,

Physiologist, in Charge of

Laboratory of Plant Breeding.

RIVERS SEA ISLAND COTTON.

History of the Variety.

This variety, the seeds of which are now distributed for the first time, was originated in connexion with the investigations of the United States Department of Agriculture on the cotton wilt, a disease which has done great damage in the South. All other methods of treatment having failed, an effort was made to produce a resistant variety. This was based on the observation that some plants remained healthy, even in the worst infected places, and it was thought that the seed from such stalks might produce other resistant plants. This was found to be the case, and several strains have been produced in this way by saving seed from healthy plants in the worst diseased areas. The seed of the best of these resistant strains is distributed with this circular, the seed having been grown, by special arrangement, expressly for the Department of Agriculture. Other selections made by the Department, or under its direction, are also being grown and tested, and will be used for future distribution.

The Rivers cotton was originated in co-operation with the Department of Agriculture by Mr. E. L. Rivers, James Island, S. C., who in 1899 saved the seed of a single plant which had survived the disease, while all surrounding plants had been killed. This seed Mr. Rivers planted in a single row in a badly infected area. In the resistant row not a single plant died, while

the adjoining rows planted with ordinary seed were almost totally destroyed.

Sufficient seed was obtained from this row to plant an acre the next year (1901). This land was also infected with the cotton wilt, but only two or three plants became affected, showing the great resistance of the new variety. In 1902, 15 acres were planted. This land was badly infected with wilt, and previous crops had been nearly destroyed in portions of the field, so that the land had been abandoned for cotton. The Rivers cotton proved as resistant here as in the previous years. An occasional plant became diseased and was pulled up, but the field as a whole was perfectly healthy and produced a large crop.

These three successful trials of this variety, corroborated by numerous experiments carried on by the Department of Agriculture with both Sea Island and Upland cotton and by the experience of several cotton planters, demonstrate that the wilt can be overcome by the use of resistant varieties, and this seed is distributed this year in Georgia and Florida to enable the farmers to test its merits and grow for themselves a stock of seed for future planting.

Cotton Wilt.

The especial feature of this variety is its resistance to the wilt, and since some who receive the seed may not be familiar with that disease, a brief description of it is included here.

The wilt disease is also known as 'blight' and 'black-root.' It is injurious to Sea Island cotton on the Sea Islands of South Carolina, and in Southern Georgia and in Florida, and to Upland cotton over wide areas in several States. It is worst on sandy soils, where it persists year after year. Prominent symptoms are the wilting of the plants, which are dwarfed or killed, the brown discoloration of the inner wood of stem and root, and a tufting of the small rootlets.

The wilt is caused by a parasitic fungus in the soil, which enters the roots and grows upward through the water-carrying vessels of the stems, which it clogs. It is aggravated by continuous cropping in cotton, but cannot be remedied by rest or rotation, since the fungus can live in the soil for an indefinite time after it has once obtained a foothold. It is not due to the poverty of the land nor to the use of commercial fertilizers, and can not, so far as is known, be cured by adding any fertilizer or other substance to the soil.

Control of the Wilt.

The only remedy known is the use of resistant varieties. When the land is badly affected by wilt and seed of resistant cotton cannot be had, some other crop than cotton should be planted.

In all cases, even where the disease does not occur or where a resistant variety is available a rotation of crops is to be recommended, such as corn with cow peas or pea nuts; second,

velvet beans; third, cotton; or, first, corn with cow peas or pea nuts; second, oats followed by cow peas; third, cotton.

Directions for Planting.

In order to test fully the resistant qualities of the variety, this seed should, if possible, be planted on land where cotton has in previous years suffered badly from wilt (black root). Do not plant Upland cotton near the Sea Island. Much of the 'running out' of the long staple cotton in South Georgia is due to accidental hybridization with neighbouring fields of short staple cotton. Since only a small quantity of seed can be had, unusual care ought to be taken in planting to make the seed go as far as possible. The land should be well fertilized and cared for in order to produce a large crop of seed. The Rivers cotton is resistant to wilt, but not necessarily so to rust and other troubles due to poor soil. To secure the best results, therefore, plant the seed on good soil and use from 400 to 600 ℔. per acre of commercial fertilizer or its equivalent in stable manure or compost.

In land of ordinary fertility plant in rows 4 feet apart, with the plants 18 inches apart in the row. In rich soil make the rows 5 feet apart, with 20 to 22 inches between the plants. The Rivers cotton is a low, compact variety, and can be planted closer than the average Georgia Sea Island cotton. To economize seed in planting, drop by hand three to five seeds in a hill, cover lightly, and thin out to one in a place.

In order to give an exact report at the end of the season, the field where this seed is planted should be measured and the yield determined by actual weighing when the crop is picked.

Picking.

In picking Sea Island cotton much more care should be taken than is necessary with the Upland cotton. Pick often to avoid injury by the weather. Sun the cotton on a low arbor after picking to dry it, and sort out all trash, yellow and immature cotton, etc., before ginning, as all these impurities injure the sale of the lint. The high prices obtained for the best grades of Sea Island cotton are due in part to the extreme care taken to remove all trash before marketing.

If your trial of this variety results satisfactorily, save all the seed carefully, as it will be difficult to get more from any source. Gin the cotton separately and clean the gins to avoid mixture with inferior varieties.

Characters of the Rivers Cotton.

Plant resistant to wilt, vigorous, compact, pyramidal, branching near the base; limbs, small, close-jointed, bearing heavily; bolls medium size, three- to four-lobed; seed small, black, well covered; lint 28 per cent.; staple 2 inches long, cream-white, fully to extra fine. Time of maturing early.

Continual Selection Necessary to Maintain Quality.

The qualities of resistance, bearing, etc., characteristic of this cotton, will be found to be thoroughly fixed

in the seed distributed. It cannot be expected that they will be maintained indefinitely, however, unless careful annual selection of seed is practised. Though the variety is highly resistant to wilt, there will be occasional individuals reverting to the original type and becoming attacked by the disease. All such should be weeded out and destroyed.

The following method of selection is recommended for keeping up the quality of the variety:—

1. *To obtain seed for the main crop.*—Pull up all diseased or inferior plants and all hybrid or barren stalks, saving seed only from good plants in the general field.

2. *To secure an improved stock for future planting.*—Select from the general field a few plants of the greatest excellence, marking them with a cloth. Leave these unpicked till the middle of the season, then compare them critically with reference to bearing, length, and quality of staple, resistance to wilt, etc., and *choose from this number a single plant which combines the most desirable* qualities. Save all the seed carefully and plant separate from the main crop the next year, one seed in a hill, to secure as great a yield as possible. This cotton, planted by itself each time will give sufficient seed the third year to plant the whole crop. This selection should be carried out every year. The propagation from single plants insures a uniformity that can be secured in no other way.

This is the method practised in the Sea Islands, and if it were done in Georgia and Florida, there would be less trouble with the running out of the cotton.

W. A. ORTON.

SEA ISLAND COTTON, NO. 224.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Washington, D.C., February 1, 1903.

Dear Sir: We send you, herewith, 1 peck of seed of Sea Island cotton, No. 224. This is a selection resistant to the wilt disease. It is distributed for trial under our Department number rather than as a named variety, but if it proves desirable to continue its cultivation, a name will be given to it later.

It was originated by selecting, from a field badly affected by wilt, two plants that had remained healthy. The seed obtained was planted on wilt-infected land the two years following, where it continued to resist the disease, although adjoining cotton was killed. These two successful trials indicate that its wilt resistance is well fixed, and it only remains to establish in this strain the desired commercial qualities, such as length and fineness of staple, uniformity, and productivity.

'No. 224' was developed from one of the coarser kinds of cotton grown on the Sea Islands, and more attention was paid to securing wilt resistance than fine quality. For this reason it is not equal to the best varieties grown on the Sea Islands, though it is of the grade of cotton for which there is most

demand in the market. The price obtained for the crop of 1902 was 24 cents per ℔., but the factor informed us that it was marketed 'in such a bright and showy condition that it was placed on that account in a higher grade than its staple warranted.' These facts are stated plainly in order that the planters, who test it, may not be disappointed in the results. The Department recommends it for its wilt resistance only, but believes that it is worthy of trial as a basis from which desirable strains can be developed by the methods of selection familiar to Sea Islands planters. The fact that this is not a fine cotton should not be taken as an indication that quality need be sacrificed in securing resistance to wilt. Our experience leads us to believe that wilt-resistant strains can be obtained of any degree of fineness desired, depending on the quality of the plant chosen at the beginning of the selection.

The method of selection that we have found to give best results in breeding wilt-resistant varieties is essentially the same as that usually practised for improvement of quality. It is necessary that the first selections should be made in a field known to be thoroughly infected with the wilt disease, so that every healthy plant can be assumed to be resistant. Select only those plants that show no trace of the wilt disease. Several of these most prominently resistant plants should be marked and examined critically. Eight or ten, that have the finest and longest staple and are most productive, should be retained, and the seed of each plant kept separate. The next year these lots of seed should be planted side by side on badly infected land and the progeny compared carefully with especial reference to power shown of transmitting the resistant quality. If the descendants of any plant show many diseased stalks, the whole selection should be discarded. It will be found that in the most resistant strains almost no susceptible plants will appear. Of the resistant strains, only the one having the best commercial qualities need be retained after the second year; but the first year it is well to start with several plants, as some often turn out to be non-resistant.

To insure the maintenance of uniformity and good quality in the resistant varieties, the selections should be repeated every year. The evidence we have now shows that the resistance to wilt can be maintained in this way without difficulty. A resistant variety will run out if neglected, just as any kind would do.

Future distributions of seeds—The Department of Agriculture is now growing a number of wilt-resistant selections of Sea Island cotton, which it is intended to distribute among the planters as soon as a sufficient quantity is obtained. Some of these may be better than the 'No. 224', but in the meantime it is hoped that the planters will continue the work of originating resistant strains for themselves, as so many are now doing.

W. A. ORTON.

THE IMPROVEMENT OF SEA ISLAND COTTON BY SEED SELECTION.

The following clear and concise account of the methods suggested to be adopted by growers to improve Sea Island cotton by seed selection is taken from a paper by Mr. Herbert J. Webber, in the United States Department of Agriculture *Year-book* for 1898 :—

The methods of selection pursued by certain growers of Sea Island cotton through many years are the most careful and painstaking known to the writer, and a description of these methods is given as an illustration of the actual procedure in continuous selection.

According to tradition and the reports of growers, Sea Island cotton, when first introduced into this country from the West Indies, was a perennial, unsuited to the duration of the seasons of the latitude of the sea islands off South Carolina and Georgia, where it seldom matured fruit. However, through the selection of seed from early-maturing individual plants and through better methods of culture, there has been developed an improved race, which now seems to be thoroughly adapted to the conditions of growth in the region referred to. Furthermore, under the continuous and rigorous selection, to which the plants have been subjected, the fibre has been gradually improved, and now that produced along the coast and on the islands lying off South Carolina and Georgia is considered superior to that grown in any other part of the world. The custom of carefully selecting the seed has grown with the industry and may be said to be inseparable from it, and it is only by such careful selection that the staple can be kept up to its present superior excellence. Several different strains have been developed and are maintained by different growers selecting with different ideals in view. The method described below is that which has been employed for many years by Mr. W. A. Clark, of Columbia, S.C., on his James Island plantation, and to him the writer is greatly indebted for the details. This method and similar ones employed by numerous other growers are applicable, with slight variations, to most of our common crops, such as corn, wheat, etc.

FIRST-YEAR SELECTION.

(1) The first selection is made in the general field, where there are a great number of individuals growing and consequently, abundant opportunity for choice. Each plant in the field is somewhat hastily examined, special attention being given to the vigour and productiveness of the plant, the strength, silkiness, and general quality of the staple, etc., and a number of those, which appear to be distinctly superior to the general crop, are marked.

(2) The selected plants are then compared, and several of the best selected for more careful comparison, field notes on

these being recorded and preserved for comparison with more critical notes to be taken later. The following is an illustration of field notes copied from Mr. Clark's selection notes of 1895: 'No. 1, stalk medium, pod medium, bearing close, fairly double, lint fair; No. 2, stalk medium, pod medium, bearing good, lint fair; No. 3, stalk large, pod large, bearing close and double, lint fine and long; No. 4, stalk large, pod medium, bearing extra close and double, lint fine and long; No. 5, stalk medium, pod medium, bearing close and double, lint fine and long.'

(3) Critical house examinations of the specially selected plants are now made at leisure, the fibre being 'pulled' and carefully examined and graded according to (*a*) covering of seed; (*b*) size of seed; (*c*) length of staple; (*d*) fineness of staple; (*e*) uniformity in length (an important feature in preventing loss in manufacture). The following table, based on critical pulling, shows how carefully the record is kept:—

Results of examinations of specially selected plants:—

Factors used in grading.	No. 1	No. 2	No. 3	No. 4	No. 5
Covering ...	First	Fifth	Second	Fourth	Third
Size of seed ...	Second	Fifth	Fourth	Third	First
Length ...	Third	Fifth	Fourth	First	Second
Fineness ...	Fourth	Fifth	Third	First	Second
Uniformity ...	1	1	1	1	1

Note—All stalks present good appearance in field except No. 3, which is defective in middle of top.

'Valuing the first place as 5 and the fifth place as 1, and in like manner intervening positions, the general grade or rank of stalks, valuation of uniformity being omitted, as it is the same in all, would be as follows: No. 1, 14 points; No. 2, 4 points; No. 3, 11 points; No. 4, 15 points; No. 5, 16 points. Nos. 4 and 5 would therefore seem to rank first.'

(4) The next step in the selection is the comparison of the ginning quality, that is, the actual weight of lint to seed in the individual plants selected. The nearer the weight of the lint approaches the weight of the seed, the better. In the early days of Sea Island cotton growing in the United States, the proportion of lint to seed by weight stood about as 1 to 5, but under the influence of continuous selection the difference in the ratio has been gradually reduced until now it is frequently about as 1 to 3. In order to obtain values easy to

compare, Mr. Clark weighs the seed and lint after ginning and determines the weight of unginned cotton necessary to produce a standard 300℔. bale. This is obtained by the following proportion: Weight of lint is to combined weight of lint and seed as 300℔. is to X (X equalling the weight of the unginned product necessary). To illustrate this point, according to Mr. Clark's notes the five plants above referred to ranked as follows, as shown by their ginning qualities: No. 5 required 1,001 ℔. to produce a 300 ℔. bale; No. 4, 1,001 ℔.; No. 1, 1,038 ℔.; No. 2, 1,060 ℔.; and No. 3, 1,068 ℔.

(5) To secure further evidence as to the qualities of the selections and as a check on individual judgement, the ginned fibre is sent, labelled by number, to an expert cotton commission merchant known as a factor, who judges the sample from the standpoint of the expert marketer. Of the above plants, Mr. Clark's factor selected No. 5 as outranking the others. This number being, on the whole, superior to the others, it was finally selected and the seed retained for further breeding, the other numbers being discarded.

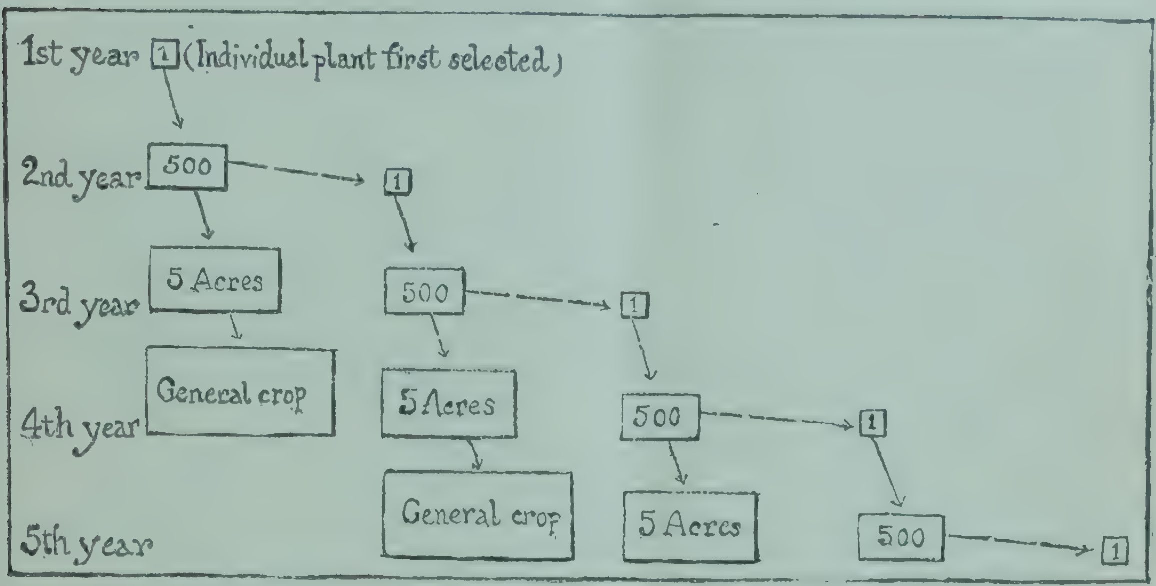
SECOND-YEAR SELECTION.

The seed of the individual plant selected the first year is planted in the spring of the second year, and as each cotton plant yields from 500 to 800 seeds, 500, or more, seedlings will probably be produced. When these reach the proper stage of maturity all are carefully examined, as in the preceding year's selections, and several chosen for further and more careful examination. These specially selected individuals of the second generation are put through the same careful tests as to covering, size of seed, length of staple, proportion of lint to seed, etc., as those of the first year's selection, and the plant found to be of particularly high grade is selected for further breeding. The seed from the remaining plants (about 500) resulting from the first year's selection are retained for planting the third year in order to obtain sufficient seed of a selected strain to plant the general crop.

THIRD-YEAR SELECTION.

The seed from the second year's selection is planted in the spring of the third year, and when the plants reach maturity each one is examined as in the first and second years, and an individual particularly good in all respects selected for further breeding, as in the previous years. The seed produced by the plants (some 500 individuals) resulting from the single plant selected the second year, and which are not specially selected for further breeding, are retained to plant in the spring of the fourth year in order to provide sufficient seed the fourth year to plant the general crop the fifth year. The seed from the 500, or more, unselected plants of the second year's selections are grown this year, being sufficient to plant an area of 5 or 6 acres and furnishing enough seed to plant the general crop the fourth year.

The accompanying diagram illustrates the method of selecting Sea Island cotton :



FOURTH-YEAR SELECTION.

The seeds from the specially selected plant of the third year are planted, and from the resulting 500, or more, seedlings, a particularly fine individual is again carefully selected for further breeding, as in the preceding years. The seed of the plants descending from the individual specially selected the third year is sown to obtain sufficient seed to plant the general crop of the fifth year. The seed used to plant the general crop of the fourth year is that from plants of the third year grown from the unselected plants of the second year, and thus the general crop this year is derived directly from the first-year selection, and so on through succeeding generations. (See diagram.)

PRACTICE OF GROWERS.

The foregoing description and diagram show that after the selection work is under way, special selections are made each year from the small plots of very select seed, and that the general crop is continually grown from stock descending from a single selected individual plant. In the method of selection above outlined the selection of a single individual each year only is considered. In practice, each grower generally selects several plants each year from which to breed ; for example, two being selected for superior excellence of staple, one or two for general vigour and productiveness, etc. Each of these, however, is chosen from several selected individuals, the same care being exercised as in the first-year selection. It is always desirable to choose several special plants each year as breeders, as occasionally a selected plant may prove erratic and produce seedlings materially differing from the type, even after the selection has been carried on for a number of years with the same ideal in view.

Under this continuous painstaking selection, the quality and length of the fibre have been gradually increased and the

proportion of seed to lint gradually decreased. The fibre from unselected plants is only from $1\frac{3}{4}$ to 2 inches long, while that from the selected strain is about $2\frac{1}{2}$ inches long and is very strong and silky. The finest grades are used to adulterate silks. These high-bred strains are maintained only by continuous selection, and if for any reason the selection is interrupted, there is a general and rapid decline in the quality of the staple. The cotton produced by these rigidly selected plants commands a much higher price than the general crop and is sold direct to manufacturers for special purposes. The price of such cotton is governed entirely by the excellence of the crop, so no regular quotations for the product of the highly selected plants are given in trade journals. The finest grades from the selected plants, the writer is informed, sell for from 50 to 60 cents per ℔., while the ordinary Sea Island cotton is quoted at from 15 to 30 cents per ℔.

Different growers select with different ideals in view, and the crop of each plantation may differ greatly in quality and value from that of adjoining plantations. Mr. Clark selects mainly with a view to increasing the fineness and length of the staple, and this is done at the expense of quantity. His fine product, however, commands the very highest price, and this compensates for the small yield. Mr. W. G. Hinson, another careful grower of Sea Island cotton, selects with a different ideal in view and has produced a strain with somewhat coarser fibre, but yielding heavier; and although the coarser grade may not bring so much per ℔., yet it may prove fully as remunerative because of the greater productiveness of the strain.

The following interesting letter from the Washington correspondent of the *New York Herald*, (reprinted in the *Agricultural News*, Vol. II, p. 277,) deserves the careful attention of those who are embarking in cotton cultivation in the West Indies :—

An article, by Mr. Herbert J. Webber, Physiologist in charge of the plant-breeding laboratory in the Department of Agriculture, on 'Improvement of Cotton by Seed Selection,' in the *Year Book* of the Department of Agriculture, published to-day, contains suggestions which, if generally adopted, would lead to a large increase in the cotton production of the United States. The extent to which this is possible by the adoption of scientific methods is shown by the fact that, while the average yield of cotton in the United States is only about 190 ℔. of lint per acre, yields varying from 500 ℔. to 800 ℔. per acre, are frequently obtained on many large carefully cultivated tracts. Mr. Webber does not believe that it is possible greatly to increase the acreage devoted to cotton in the United States. He says there is little opportunity for extending the industry into new regions, and while a much larger acreage of cotton could be grown in the old cotton-producing States, if necessity demanded it, there is a tendency in those States toward diversified farming rather than further specialization in cotton production. He concludes, therefore,

that the most important problem now before cotton growers seems to be that of increasing the production on the same acreage, rather than extending the acreage itself. He thinks that, while cotton growing in other countries is capable of being considerably extended, such extension will doubtless be slow and will only slightly affect the industry in this country, and that the American planter should strive, by the application of improved methods and machinery and the use of improved varieties of cotton, yielding more and better staple, to keep well in advance of competitors in foreign countries, where cheaper labour is available.

Mr. Webber recognizes that the character of the soil is the factor of greatest importance. He believes, however, that there is great opportunity of improving the industry on all lands, both good and poor, and he estimates that the cotton crops could be doubled, on the same acreage now grown, by proper attention to two factors necessary to success, namely, the universal use of good cotton seed and careful methods of tillage and fertilization. While both of these factors contribute largely to success, Mr. Webber believes that the importance of good seed is probably more commonly overlooked than the matter of cultivation. His observations show that fully half the planters use seed taken at random from public gins, about which they know nothing other than that it was produced somewhere in the same vicinity; and he says: 'As well might the breeder of fast trotting horses introduce dray animals into his stables, or the breeder of intelligent hunting dogs introduce ordinary mongrel curs into his kennels. The use of good seed and its production by a regular system of selection is just as important a factor in the production of the crops as that of cultivation. No intelligent method of farm management disregards the production and use of good seed. The day, when growers can afford to plant any sort of cotton seed, has passed. Only seed of a known variety, selected because of its desirable qualities and adaptability to local conditions, should be planted.'

The traditional belief that an occasional change of seed is necessary if good crops are to be regularly secured is attacked by Mr. Webber, who contends that, to secure the best results, plants must be bred and adapted to soil and climatic conditions, and that cotton planters and growers of cereal crops as well, if they are to obtain the best results, must select their seed in the locality where it used to be regularly grown in order to adapt it to the particular soil and climatic conditions.

The paper outlines a system of selection based on the principle that, while plants reproduce their main characters unchanged, and the stability of the cultivated plants and natural species depends upon this law of heredity, still they are not absolutely fixed and stable, but are very unstable and highly variable in minor characters. The system outlined, which is one that any planter can carry out on his own plantation, is based on the use of the seeds of only such plants as show the characteristics which it is desirable to reproduce—such as quantity of production, length of fibre

and earliness of maturity. It is recommended that, after these plants have been carefully selected, the seed from the middle pickings of each plant be carefully gathered ; that that from each plant be ginned separately, in a gin that has been carefully cleaned so as to prevent mixture of unselected seed, and that the seed of each plant be planted separately, the following year, so as to test its quality for the reproduction of the qualities desired to be perpetuated. All plants that do not come up to the standard are to be discarded in the second year, and the seed of only the very best are to be used for planting the third year. By the beginning of the fourth year, a sufficient supply of highly selected seed for seeding a large plantation will be secured. The system of selection can be indefinitely continued, however, from year to year, on a tract of ground set apart for that purpose, and thus the quality of the cotton can be kept to a high standard or constantly improved.

Mr. Webber makes an important suggestion as to the possibility of combating the Mexican cotton boll weevil by seed selection. In examining fields of Upland cotton in different parts of Texas, he observed occasional individual plants, in badly infected fields, that had set and matured almost all of their bolls, while adjoining plants were almost denuded. Whether such plants possess a degree of resistance or not, and whether this possible resistance will be transmitted to their progeny, he says, remains to be determined : but he thinks it probable that some plants may be discovered and propagated which will be distasteful to the weevils. He tells of experiments in Texas in 1901 and 1902 with varieties of Egyptian cotton for the purpose of noting the effect upon them of the boll weevil. The weevil was found to be destructive of all the varieties observed except the Mit Afifi cotton. Three acres of this variety were grown on land where the crop had been destroyed by weevils the previous year. About 200 feet distant was a small patch of Upland cotton. The weevils appeared on the Upland cotton early in the season and almost entirely destroyed it. They did not appear on the Mit Afifi until the middle of October, and damaged it very little. The Mit Afifi yielded about 1,066 ℔. per acre while the Upland variety yielded about 200 ℔. per acre. This was in spite of the fact that the Upland cotton was much earlier than the Egyptian, and would normally be expected to produce a much larger crop in the boll weevil district owing to this fact.

CULTIVATION OF SEA ISLAND COTTON.

The following description of the cultivation of Sea Island cotton in the southern United States is taken from a standard work on cotton, published in 1898, which deserves to be carefully studied by everyone interested in the cotton industry.* The writer expresses his indebtedness for much of the information contained in this extract to an article in the South Carolina *Handbook* by Mr. H. Hammond :

The Sea Island cotton plant has a larger and more vigorous growth than the Upland plant. It withstands the vicissitudes of the heat and cold better, and it is less subject to disease ; so-called blight and rust do not affect it as readily as they do the Upland cotton, nor does it shed its forms and bolls to anything like the same extent. These remarks as to rust apply also to those varieties of Uplands in which the length of the staple has been improved by selection of the seed, and rows of this are often seen healthy and vigorous, while the short staple Uplands around are withered with the rust. The early growth of the Sea Island is so vigorous, that it maintains itself in fields infested with Bermuda and nut grass, as the Uplands could not. The leaves are larger, smoother, and of a brighter green than Uplands, and the flowers are larger, handsomer, and of a more golden yellow. But the bolls are smaller, and instead of being five-lobed are usually only three-lobed—these lobes being so sharp-pointed as to prick the fingers, to the serious inconvenience of pickers not accustomed to gather Sea Island cotton. Of course the small size of the bolls, requiring so many to make a pound, adds much to the expense of harvesting the crop.

On the Sea Islands of Carolina, field labour is performed almost exclusively by negroes. Nearly all of them are engaged in farming on their own account ; a large number own farms ; a still larger number rent land for cultivation, and even the labourers are paid, most generally, by granting them the use of so many acres of land, for certain stipulated services. The total number of farms on the islands is stated to be 5,453, but the number probably exceeds 6,000, the enumerators having had the lands and crops, cultivated by renters, returned by the landowner, and consolidating them as being in some way under one management, when they were in reality entirely independent —an error ever likely to occur and sometimes quite difficult to avoid, and which has no doubt caused the number of farms to be underestimated and their size overestimated in many sections of the south. The largest number of acres of Sea Island cotton, planted under one management, nowhere exceeds 100 acres. The white planters probably do not average more than 30 acres, and this necessitates that they should be landlords of considerable estate. For as the labourers are frequently given 5 to 7 acres for two days' work in the week, and as this two days' work per week does not suffice for the cultivation of more

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* *Cotton:* Its Uses, Varieties, Fibre structure, and Cultivation. By C. P. Brooks. London: E. and F. N. Spon, Ltd., 125 Strand, 1898.

than 4 acres, to cultivate 30 acres of cotton under this system requires 75 acres of land; add to this the amount usually planted in corn and other crops, and we shall have 120 acres. As under the best system the land lies fallow every other year, the planter of 30 acres of cotton will require 240 acres of open land, and as scarcely one-fifth of the land is under cultivation, such a planter will probably own some 1,200 acres. Thus there is no proportion between the size of the farm actually cultivated and the land holding—the first being quite small and the last large. This state of things is owing to absence of capital and the low price of land and labour; lands which were worth \$50 to \$60 an acre more than half a century ago, and which had increased in value down to 1860, being until recently either wholly unsaleable or selling at \$10 per acre or less.

On James Island, which at this time is perhaps under a more progressive system of culture than the other Sea Islands, labourers are paid cash for their work, at the rate of 50 cents per diem and \$10 per month, with board—the latter being a ration of 3lb. of bacon and 1 peck of grist a week, with shelter and fuel. The soil and the condition of the labourers are reported as improving, and cash wages are considered preferable to the share, or the land, system of payment. Arable land rents here at \$2 an acre per annum. The price of land is from \$15 to \$30 an acre. A few labourers own their own houses, but very few own any farming land.

On John Island, cash wages are from \$8 to \$10 a month with board. Most of the labourers, however, are engaged for two days' work a week by allowing them a house, fuel and 6 or 7 acres of land free of rent. The report is that the system is not satisfactory. The land worked by the landlords is improving: that worked by the labourers on their own account is deteriorating rapidly. The labour is not so easily controlled as when cash wages are paid. The lands vary greatly in price—prices ranging from \$2·50 to \$20 per acre, with some lands valued recently still higher. Rent is higher than on James Island, in consequence of a system that increases the demand by multiplying small farmers, and it is about \$3 per acre per annum.

On Edisto Island, the two days' system prevails. The average yield of cotton on Edisto Island is a bale to 2·6 acres; for the six largest planters it is a bale to 1·7 acres. Considering the quality of the staple produced, it may be safely said that the larger farms yielded between two and three times as much as the small ones. Lands here are worth from \$10 to \$25 per acre—formerly they were worth from \$50 to \$70 per acre. Small tracts rent for about \$4 per acre per annum, larger tracts for less. This state of things tends to reduce the saleable value of lands, while it increases their rental value.

A mule can do the ploughing required in the cultivation of 30 acres in Sea Island cotton, and can, in addition, cultivate a sufficiency of land to supply corn for its own feed, perhaps something over. The first step in the preparation of the land is to hoe off the weeds ('hurricane'), cut up the cotton stalks, and pile and burn this litter. This costs 40 cents per acre. Bushes are grubbed up at a cost of 7 cents per acre. The land

is not broken up broadcast with the plough, but early in February two furrows of a single-horse turning plough are run in the old alleys, making a trench 7 or 8 inches deep. In this furrow a subsoil plough may, or may not, be run, according to the character of the subsoil. Wherever under-drainage is practised, as on James Island, the furrow is generally used. Before ploughs came into use this trench was never made, and even now it is omitted by some of the most successful planters. Into this trench, or into the middle of the alley, where there is no trench, the manure is placed. This consists usually of about twenty cart loads of marsh mud and 1,000 ℔. to 1,400 ℔. of cotton seed. Stable and lot manure, together with composts of marsh mud and rushes, are also applied in the furrow at the rate of forty cart loads per acre on such a portion of the land as the limited number of stock enables the farmer to treat in this method. On the lines of manure thus laid down, a certain quantity of commercial fertilizer is drilled. This practice, wholly unknown formerly, is very common now, even the smallest negro farmers often going heavily into debt to obtain these fertilizers from the storekeepers. They are handy, obviate the labour and care of stock and the forethought and toil of collecting and manipulating composts. On James Island and John Island a mixture, consisting of 250 ℔. of acid phosphate, 200 ℔. kainit (German potash salt) and 200 ℔. calcined marl, is applied per acre. On Edisto Island are used 200 ℔. fish scrap (half dry in barrels), 200 ℔. kainit and 200 ℔. acid phosphate per acre. On St. Helena Island little fertilizer is used. Cotton seed is worth $15 to $20 per ton, and the commercial fertilizers from $15 to $30 which would make $15 an acre the cost of the manure among the best farmers.

The land is now ready for listing, which is done by hauling on to the manure with a hoe the soil from the tops and sides of the old beds. A more recent practice is to lap in with two furrows of a turning plough on the manure. This costs only $17\frac{1}{2}$ cents per acre, while the listing with the hoe costs 80 cents, although the latter has the great advantage of bringing all the vegetable mould and humus directly to the spot where the roots of the plants are to grow. Over the mass of dirt, weeds, manure, etc., thus collected in the old alley, a double roller, 5 feet from centre to centre and weighing about 800 ℔., is passed to press together and compact the whole, completing two rows at a time. All this should be completed by the 1st. to the middle of March, and the bed is then built up by lapping in two more furrows on a side with a single or double-horse turning plough.

The land is now ready for planting, which may begin any time after March 20, but the 1st. to the 10th. of April is the time preferred. Cotton planters are not used: three hands do this work; the one ahead chops a hole with a hoe on the top of the bed at intervals of 12 to 18 inches; another hand drops eight or ten seeds into each hole, and the third follows and covers carefully with the hoe. Three or 4 pecks of seed are used to the acre. The seed makes its appearance above ground in eight to twelve days after being planted, and the stand is perfected from the second week in April to the first week in May. Hoeing begins about May 1. The second

hoeing takes place the last of May. The ploughs then break out the middles (the spaces between the new beds where the old beds stood). The hoe hands follow and pull up the loose dirt left by the plough to the foot of the cotton. This is called hauling; by it the new bed is completed, the cotton is kept from 'flagging' (falling down), and the grass is kept under. It costs 80 cents per acre. At the second hoeing some stalks are thinned from the bunch in which the seeds break the ground, and at each succeeding hoeing and hauling other stalks are removed, until in July only one stalk of each bunch is left. There are four hoeings and four haulings by the last week in July, one or more furrows with a sweep plough being run through the middle previous to each hauling. By the last of July the culture is completed, except to run a furrow with the sweep between the rows in August, to destroy grass and keep the cotton growing.

The first blossoms appear about the middle of June when the cotton is 15 inches high, and the bolls open towards the end of August, when the plants have obtained a growth of 4 to 5 feet. Cotton picking commences from the last week in August to the second week in September. For the first picking, while the cotton is thin, $1\frac{1}{2}$ cents per ℔. seed-cotton is paid. Subsequently the price is 1 cent per ℔, never less, until the last of November, when it rises again to $1\frac{1}{2}$ to 2 cents. By December 15, the crop is gathered.

When the cotton has been picked, weighed and housed, it is next spread out in the sun, on what is called 'an arbour.' This is a platform usually made of inch boards, raised a few feet above the ground, and some 25 feet or more square. Here the sun and air dry the cotton, preventing it from heating, which it is liable to do when stored in bulk, and it is also thought to cause the lint to absorb some of the oil in the seed. which adds to the silky lustre of the fibre. After being thus dried, it may be either stored or passed at once to the 'whipper', a machine that knocks out the dust and sand, and leaves the cotton whiter and more open. Formerly, when the price was higher than it is at present, it was all assorted. A hand was given 150 ℔. of seed-cotton as a day's task, which he thoroughly overhauled, picked out all specks, stained cotton, fragments of leaf, etc. At present, however, this is usually done by two hands, who examine the cotton as it passes into the gin, and two others behind the gin, who pick out cracked seed and motes as the lint issues from the gin. The roller gin in some form has always been used for detaching the lint from black seed-cotton. The first roller gin used in this country was one constructed in 1788, by Mr. Bissell, of Georgia. It consisted of two short wooden rollers moving in opposite directions, each turned by a boy or girl, and giving, as a result of a day's work, 5 ℔. of lint cotton. To this succeeded the foot or treadle gins, imported from the West Indies, where they had been in use, having reached there with this variety of cotton seed. Other improvements took place in the roller gin, from time to time, and about 1840, F. Macarthy, of Alabama, devised a machine which bears his name and has been in use ever since on the Sea Islands. Shortly after this, small steam engines were used

with the Macarthy gin, and now oxen and horses have been discarded and all the gins on the Sea Islands are run by steam power. Two horse-power is required for each gin, which turns out on an average, a bale weighing 350 ℔. as a day's work. There is a recent English improvement of the Macarthy gin, known on the Sea Islands as the double Macarthy. This gin gives two bales in a day's work; but it requires greater skill to attend it.

The usual charge at these gins is $3\frac{1}{2}$ to 4 cents per ℔. of lint, and they are said to pay well. The cotton is packed in Dundee bagging, in round bales. No press is used, as it is thought it would injure the fibre. The work is done by hand, the cotton being beaten into the bag with a pestle. At the large gin house on St. Helena, however, even this work is accomplished by machinery. The bag is conveniently suspended from an iron hoop, and a disc of two-inch plank, exactly fitting the bag, and moved by steam, pushes the cotton in, securing greater despatch and accuracy in the packing.

What has been written refers distinctly to the Sea Islands. A considerable quantity of long staple cotton in addition is grown on the mainlands and is known as Floridas, Santees, and as Mains. The general economy of the culture is the same as on the Sea Islands. The seed is obtained annually or biennially from the islands, as it is thought to deteriorate very rapidly on the mainland. In the absence of determinate experiments for a series of years, it is not easy to say what the cause of this deterioration is, or even if it is due to causes of a permanent character. That the seed does deteriorate is a fact beyond question.

The cost of production may be considered from two points of view. First, the actual cost to certain producers of whom inquiry has been made. Second, what may be termed the rational cost, that is, the labour, material and capital, necessarily expended in production, directly or indirectly, by the producer himself, or by some one else. The first is real, but by no means expresses everything involved. For instance, on unsaleable land, a landlord, with little or no expenditure of capital, may produce a certain amount of cotton with labour given in return for debts that could not be otherwise collected. Such cotton would cost almost nothing to the producer. Between this and the opposite extreme, where the land had been bought above its real value, and a large expenditure made in the culture, there is every variation of individual experience—from one of immense profits to one ending directly in bankruptcy. The rational cost, on the other hand, is purely theoretical; in estimating the cost of each item of expenditure, it must be generalized and reduced to an average that does not, perhaps, conform exactly to the experience of any individual. It summarizes these items, and leaves them recorded for consideration. Both methods are given. Messrs. Hinson & Rivers, on James Island, say $80 a bale of 400 ℔., or 20 cents per ℔. Dr. A. B. Rose, of Charleston, puts the cost at $70 an acre, which should yield a bale of 350 ℔., which gives likewise 20 cents per ℔. One of the most, if not the most successful among

Sea Island planters, Mr. J. J. Mikell, of Edisto, says the cost is 15 cents per ℔. there.

Before considering the rational cost, a word should be said as to the amount of production. The highest yield on record to one acre is 566 ℔. of lint, on a single acre on Mr. Schaffer's place on Wadmalaw Island. A planter on John Island made an average of 290 ℔. of lint per acre, on a tract of 20 acres, while small farmers in the same locality produced only 50 ℔. to 75 ℔. lint per acre. On Edisto Island, there is a tract of 100 acres, producing 210 ℔. of lint per acre, and conservative farmers there consider that 200 ℔. of lint on the larger farms, year in and year out, to be an average yield of fine staple. In Mills' statistics of South Carolina, published in 1825, it is stated that a farmer on Edisto Island produced on an extensive scale, an average of 270 ℔. of clean cotton to the acre. He also states that there were lots of lands that had produced 435 ℔. of lint to the acre. From which it would appear that the soil, climate and old methods of culture had a capacity not very far inferior to that, with which the invention of fertilizers and of improved implements and methods at the present time, endow this locality.

SEA ISLAND COTTON CROPS, EXPORTS AND UNITED STATES CONSUMPTION (SHEPPERSON).

Season.	Florida Crop.	Georgia Crop.	South Carolina Crop.	Texas Crop, etc.	Total Crop.	Exports to Great Britain.	Exports to the Continent.	Takings of U.S. Spinners.
1874-75	8,139	1,074	7,308	166	16,687	13,139	1,907	2,192
1875-76	7,598	2,121	4,722	74	14,515	11,591	1,345	1,915
1876-77	10,832	2,558	4,933	29	18,352	11,865	1,369	4,068
1877-78	11,675	3,556	6,249	30	21,510	12,594	3,701	6,451
1878-79	10,214	2,052	7,133	202	19,601	10,456	2,242	6,688
1879-80	11,300	3,420	10,142		24,862	13,729	3,294	9,389
1880-81	16,950	3,179	14,868	24	35,021	20,259	4,136	11,270
1881-82	20,992	6,049	10,796	25	37,862	22,303	2,453	14,762
1882-83	16,898	3,126	16,591	94	36,709	21,565	1,892	13,573
1883-84	16,762	1,399	7,329		25,490	12,166	1,413	11,674
1884-85	23,526	4,327	12,588	11	40,452	18,422	3,143	17,358
1885-86	23,501	5,780	8,497		37,778	14,748	1,680	19,973
1886-87	29,991	6,411	8,735		45,137	25,216	1,435	20,515
1887-88	22,614	8,304	8,561		39,479	18,698	1,915	19,560
1888-89	22,471	12,000	9,618		44,089	21,515	1,811	20,132
1889-90	23,918	13,629	9,256		46,803	25,991	2,251	19,124
1890-91	22,214	29,613	16,306		68,133	34,300	4,823	26,602
1891-92	17,059	30,576	11,499		59,134	24,778	2,653	32,279
1892-93	9,882	28,324	7,212		45,418	20,650	1,890	22,927
1893-94	19,107	39,367	2,578		61,052	33,385	4,636	23,516
1894-95	15,031	53,703	5,894		74,628	35,033	5,711	34,765
1895-96	20,771	61,312	9,971	991	93,045	43,174	7,269	40,092
1896-97	26,219	65,040	10,701	2,597	104,557	47,272	11,180	41,676

COST OF EACH ITEM OF LABOUR AND MATERIAL EXPENDED IN THE CULTURE OF AN ACRE OF SEA ISLAND COTTON.

Items.	One.	Two.	Three.	Four.	Five.
	$ c.	$ c.	$ c.	$ c.	$ c.
Rent or interest on money invested in lands ...	5 00	5 00	5 00	3 00	3 00
Wear and tear of implements	1 00	1 00	1 00	...	...
Cleaning and burning weeds and stalks	40	40	40	...	30
Other cleaning up... ...	07	07	07	25	25
Digging and carting salt mud	1 00	...	...	...	...
Spreading salt mud ...	80	...	...	...	...
Cotton seed for manure, 20 bushels at 30 c.	6 00	...	...	...	...
Lapping mud and seed in with two furrows, or rolling ditto	12½	12½	...	15	...
Fish scrap, 200 ℔, and spreading, 15 c.	2 65	...	...	...	...
Kainit, 200 ℔.	1 50	...	...	...	...
Acid phosphate, 200 ℔. ...	2 00	...	...	..	...
Spreading last two, 15 c. each	30	..	...	...	...
Commercial manures ...	...	6 50	6 50	10 00	2 50
Home-made manures ...	...	7 25	7 25	2 00	50
Applying manures ...	...	1 45	1 45	55	10
Bedding up with plough ...	25	40	40	50	50
Splitting middles ...	...	25	25	50	50
Breaking out ridge of old bed	12½	12½	12½	...	...
Carried forward $	21 22	22 57	22 44½	16 95	7 65

COST OF EACH ITEM OF LABOUR AND MATERIAL EXPENDED IN THE CULTURE OF AN ACRE OF SEA ISLAND COTTON.

(*Concluded.*)

Items.	One.	Two.	Three.	Four.	Five.
	$ c.	$ c.	$ c.	$ c.	$ c.
Brought forward ...	21 22	22 57	22 44½	16 95	7 65
Planting	45	50	50	50	50
Replanting	20	25	25	25	25
Seed	30	30	30	1 50	40
Eight to ten hoeings and haulings	5 60	5 60	5 60	6 00	6 00
Ploughings with sweep plough	25	25	25	2 50	2 50
Thinning and regulating stand	12½	12½	12½	50	50
Cleaning ditches	10	10	10	...	...
Picking cotton	8 00	8 00	8 00	11 20	4 00
Sunning and drying cotton...	15	15	...	...	...
Ginning, cleaning and packing	3 00	8 00	7 00	8 80	3 50
Bagging and twine per bale	55	55	55	55	27
Hauling to gin	..	40	40	50	25
Hauling to steamboat and freight to city	50	50	50	50	25
Storage, insurance, weighing, drayage and selling ...	2 50	2 50	2 50	2 50	1 25
Foreman's wages and rations	2 75	1 50	...	...	...
Total $	45 69½	51 29½	48 52	52 25	27 32

The previous table presents the rational cost, giving an itemized account of all expenditures, as reported by intelligent Sea Island planters. The first three columns are from Edisto, the yield being placed at 200 ℔. of lint cotton to the acre. Number four is from James Island, the yield taken at 280 ℔. of lint per acre. Number five represents the average expenditures of the better class of small farmers on John Island.

It would be a still more difficult problem to arrive at a satisfactory estimate of the profit per acre to the farmer. This would vary, in the first place, according to the grade of cotton produced, the prices fluctuating with the fineness of the staple, from 30 cents all the way up to $1·10 per ℔. The value of the cotton, too, would depend greatly on the handling of the crop, whether it was picked in time, properly stored, sunned, dried, ginned, and moted,—in all of which operations the skill, care and forethought of the farmer would count for a great deal. But if we place the price of cotton at 40 cents per ℔., we may offer the following estimates as coming somewhere near the correct deductions to be made from the data furnished by the foregoing figures:—

COST OF SEA ISLAND COTTON PER POUND AND PROFIT PER ACRE.

	One.	Two.	Three.	Four.	Five.
Cost per pound ...	$22\frac{8}{10}$c.	$25\frac{1}{2}$c.	$24\frac{1}{4}$c.	$18\frac{3}{5}$c.	$27\frac{3}{10}$c.
Cost plus value of seed produced and less interest on investment ...	$17\frac{9}{10}$c.	$20\frac{7}{10}$c.	$19\frac{3}{10}$c.	$15\frac{1}{10}$c.	$21\frac{3}{4}$c.
Profit per cultivated acre ...	$45·20	$38·20	$41·40	$69·72	$78·25

These figures can, of course, only be approximately correct, but the wide difference that prevails between large farms and high culture, and the small farms and insufficient culture, is a hopeful indication that the efforts for improvement have met with success, a success that would be much enhanced if we estimate the improved value of soil itself, where high culture has been practised.

COTTON CULTIVATION IN THE WEST INDIES.

The cultivation of cotton has only been revived on a moderately large scale in the West Indies during the last three years. The first experiments were started at St. Lucia by the Imperial Department of Agriculture in 1901.

The following particulars of the first efforts to cultivate cotton at St. Kitt's, Antigua, Montserrat and Barbados during the season 1902 are necessarily incomplete and give the results of only one year's trial, in some cases under unfavourable conditions and with an imperfect knowledge of the requirements of the plants. There is added an account of the small, but interesting, cotton industry that has been carried on at Carriacou, one of the dependencies of Grenada, for many years :—

ST. KITT'S.

The following is contributed by Mr. William Lunt, Curator of the Botanic Station at St. Kitt's-Nevis :—

The most suitable land for cotton in St. Kitt's is that which produces the best canes, and which has been constantly manured and regularly tilled in the course of cultivation, and preferably the low-lying and wind-sheltered portions of estates which have been lying fallow for some time.

In the case of fresh land, it should, wherever possible, be close-ploughed and afterwards ploughed into furrows 3 or 4 feet apart which latter might be subsoil-ploughed with advantage. When ploughing is not practicable the land might be 'holed,' that is, ridged and furrowed with the hoe as for cane with the exception of cross-holing, and the bottoms of the furrows thoroughly forked.

In cases where cane lands are at once to be converted into cotton lands, it is not essential that the cane stumps should be dug out before the first planting, they might be covered over by the cane trash, which should then be lightly covered with earth. The spaces between the rows should then be thoroughly tilled either with a plough and harrow or by forking, and when this is done the land is ready for sowing ; in the following year when the stumps have decayed the land might be close-ploughed and specially lined for cotton. In St. Kitt's, owing to the very friable nature of the soil and the small rainfall, it is necessary to prepare the land with ridges and furrows as a means of conserving water and for the prevention of 'washing,' that is, damage from storm water.

Where the preparation of fresh land has been carefully conducted, further lining will be unnecessary, and the seed may be planted in the furrows ; in converted cane land the seed is to be planted between the original rows of cane ; with 6 feet spaces, two rows of seed could be planted, but with 5 feet spaces, one row would be more advisable and the seeds might be sown at closer intervals, though 5 feet rows are not to be

recommended except in specially rich soils or in cases where there are special reasons for adopting them, as in the case of cane land just converted, etc.

The sowing of the seed is a simple operation consisting of placing four or five seeds about $1\frac{1}{2}$ to 2 inches below the surface of the soil at regular intervals in the furrows, the seeds, however, must not all be placed in one hole, but very slightly apart from each other, so as not to interfere with the regular distances in the row. When the young plants have produced one or two leaves the weaker ones should be pulled up (thinning), and when they attain a height of 4 or 5 inches all but the strongest and healthiest plant in each hole should be removed. To ascertain the distance apart, both between rows and in the rows, so as to produce the best and most profitable results, needs careful experiment. In the best lands probably 4 by 2 feet will be found most suitable, while in poorer soils 3 by 2 feet will give sufficient space. Individual fields on a estate will of course vary and planters cannot be given a hard and fast rule as to distance; the distances suggested are more or less tentative and experiments are being made to arrive at reliable data on this point.

The moulding of the plants will be partly effected during the process of weeding; but before they become so large and heavy as to be seriously affected by the wind, they should receive a systematic moulding, in order to assist towards their nutrition and to fix them more firmly in the soil.

Weeding should receive constant attention, and the land should be kept in the best possible condition until the bolls begin to form, when it will be advisable not to disturb the surface of the soil more than is absolutely necessary; the object being to preserve a surface as free from dust as possible.

A full supply of insecticides should at all times be on hand to guard against or to repel the attacks of insect pests.

It is desirable to point out that this memorandum deals especially with St. Kitt's, where climatic conditions and the extremely porous character of the soil render tillage operations of an unusual character necessary.

The following information, respecting the experimental cultivation of cotton on an estate at St. Kitt's, has been kindly contributed by Mr. A. O. Thurston:—

Cotton cultivation was begun on this property last year, when, owing to unfavourable weather, and the consequent delay in reaping a heavy cane crop, the preparation of the land was commenced much later than is advisable. The best lands were also kept in ratoon canes for 1903, and only those fields that were not considered good enough for that purpose were devoted to cotton. A limited area therefore was planted in June and July, and the whole of the crop was not got in before the end of October. Labour conditions and want of time prevented the careful lining of the land to ensure exact distances being observed in the planting of the seed. All of the fields having had canes reaped from them, and the width of the rows being in most cases 5 feet, the trash was ranged on

the old cane stumps and covered with soil. The middles were broken up with an American mould-board plough, followed by a harrow to pulverize and level the soil. A hoe gang was then put on to dig holes, into which six or eight seeds were dropped and lightly covered. In every instance, these grew regularly and little supplying was necessary. Some of the fields were planted in rows 5 feet wide, and here the seeds were placed 12 to 15 inches apart. In other fields the seeds were placed in rows $2\frac{1}{2}$ feet wide, or half the width of the original cane row, and in this the distances apart were 24 inches. In two fields the rows were made 4 feet wide, and the distance between the plants 12 inches. When these attained the height of 6 to 10 inches they were carefully thinned out, as far as possible after rain, and the number of stalks reduced to one, and in some instances to two or three. Weeding with the hoe was carried on, and the land kept free from grass and weeds until the cotton bolls began to develop, when further cultivation was stopped. Up to this time the prospect appeared very promising, when an utterly unforeseen misfortune occurred. The plants were attacked by caterpillars that answer to the description of the cotton worm in the United States. The ravages of these pests, which suddenly appeared in considerable numbers, were so thorough, that the plants were defoliated with great rapidity in field after field, and half of the entire crop was completely destroyed. In many instances the young shoots were also eaten, whereupon the plants blackened and withered. Those that had been planted early and had their bolls matured, did not suffer in the same degree, and it was from these fields that the bulk of the cotton was reaped. After the bolls opened, they were affected by a red bug which stained the cotton and thereby lessened its value. Owing to the inferior yield, 1*s.* 6*d.* per 100 ℔. of seed-cotton was paid for the picking, and even at that price difficulty was experienced in getting the work done, as the people preferred working on the neighbouring sugar plantations. The owner of this property had been to considerable expense over importing two Macarthy single action roller gins, and a baling press, and erecting a steam plant for driving them, although most of the other islands are receiving help from the cotton associations and the Imperial Department of Agriculture for the carrying on of this industry. This factory is now in good working order and is prepared to clean all the cotton that is likely to be grown in the island in the near future. Some delay was, however, experienced in getting it ready and ginning was not begun until May this year, when in addition to that grown on this property, about 6,000 ℔. of seed-cotton were cleaned for outsiders. It was found that about $3\frac{3}{4}$℔. of this were required to give 1 ℔. of lint. On account of the afore-mentioned adverse circumstances, the average yield of seed-cotton per acre was small, being not more than 400 ℔. and in no instance did it exceed 800 ℔. Advices received by last mail report the sale of the first shipments of 12,000 ℔. of lint at 1*s.* $1\frac{1}{2}$*d.* per ℔. From the experience gained during the past year, I have come to the following conclusions: (1) That the cotton industry is a promising one if the present prices last; (2) that low-lying lands capable of bearing good crops of cane are also the best

for cotton: (3) that such lands should be well tilled and kept free from weeds from the time of planting to the development of the cotton bolls; (4) that during the process of cultivation the soil should be drawn up around the plants to keep them from being injured by wind; (5) that 4-feet rows in good lands and 3-feet in hilly or exposed situations, with single plants left in 12 to 15 inches apart, are good distances; (6) that June, July and August are the best months for planting; (7) that it is necessary to have on hand spraying machines and a sufficient supply of Paris green or other insecticide, to deal with a sudden inroad of caterpillars; (8) that the red stain bug can also do considerable damage to the quality of the cotton. and efforts should be made to keep it in check; (9) that the cost of labour required to cultivate an acre, from the time of preparation to the reaping of the cotton, under conditions prevailing here in lands recently under cane cultivation does not exceed 15*s.*; and (10) that cotton is ginned much better if recently picked. In conclusion I may say that I purpose planting 350 acres in cotton this year.

ANTIGUA.

Mr. F. R. Shepherd, the Agricultural Superintendent has furnished the following information in respect of cotton cultivation at Antigua:—

SELECTION OF LAND.

So far in Antigua there has been no special selection of land for planting cotton.

On estates the land for the most part planted is that not considered suitable for cane. This may be from lightness of soil or situation on hill sides, neither of which conditions would render the land unsuitable for cotton.

In some instances good cane land has been planted in cotton.

BREAKING UP AND PREPARING LAND.

(1) *Fresh land:* Very little of this kind of land has as yet been planted in cotton, but an estimate is given showing the methods that would be employed by anyone not having a plough, and the cost per acre of the work done up to time of picking.

This estimate is calculated exclusive of any cost of clearing land of bush or coarse grass, as that could not well be charged to cotton.

The prices would also vary slightly in different localities, but these figures would represent a fair average cost of an acre on land up to time of picking:—

	£	s.	d.
Flat forking 22 lots @ 10*d.*		18	4
Fining up land with hoes		7	4
Lining land		1	4
Digging holes		2	1
Planting cotton			8
Weeding cotton		15	0
	£2	4	9

(2) *Land formerly in cane or other cultivation:* The greater part of the cotton planted in Antigua is on land of this description. On land that has recently been in canes, the trash is either taken off or ranged on cane stools in the furrows, the banks split with a light plough or forked, holes dug and seed sown.

From actual figures obtained as to cost of putting in three fields, on three different estates, it was found that the cost ranged from 5*s*. to 10*s*. per acre up to the time of planting. These fields are 7, 9 and 4 acres respectively, and the cotton is well established.

(3) *Land that has been in potatos:* The banks are dressed up with hoes and seed sown at about same prices per acre as land recently in canes.

(4) *Land that has been in Guinea corn:* The banks are split with forks and re-formed, holes dug, and seed sown at a cost of 15*s*. to 20*s*. per acre according to locality.

LINING LAND AND PLANTING SEED; DISTANCE APART.

Four feet between the rows and 2 feet distance apart has been found a suitable distance for planting and has been adopted almost universally.

Where the land is in banks of 4 feet, the cost of digging holes can be saved, the seed being planted with sticks 2 feet in length. Cost of planting, about 8*d*. per acre.

MOULDING PLANTS.

This custom does not prevail in Antigua, as it has not been found necessary.

WEEDING AND CARE OF PLANTS.

This item differs according to locality, but 15*s*. per acre can be taken as a safe estimate.

PICKING COTTON.

The area planted has been too small to form a correct estimate, and on this point, in Antigua, there is much to learn.

On a small area of 2 acres yielding 600 ℔. seed-cotton per acre, it actually cost 2*s*. 6*d*. per 100 ℔. of seed-cotton to pick, but with a larger yield and more experience it should cost much less.

ESTIMATED AREA PLANTED IN COTTON.

Seed for planting 400 acres has already been distributed by the Imperial Department of Agriculture and it is believed that at least another 50 acres will be planted, making a total of 450 acres planted this season in Antigua.

Mr. Spooner, a planter at Antigua, has been good enough to furnish the following results of experiments with Sea Island cotton at Montpelier and Dimsdale estates in that island:—

Montpelier: The size of plot was exactly 1 acre. The land chosen was in pasture and some bush, and consisted of a light

gravelly loam. The field had been in cane within the last few years, but was thrown out of cultivation when the prices for sugar and molasses became low, as the land was of too dry a nature to ratoon satisfactorily. The land was rough-weeded and cleared of bush, close-ploughed, chopped into tilth with hoes, lined and planted. Owing to the drought, the seeds could not be planted until October 30, 1902. Heavy rains fell in November, and the plants grew rapidly, the first flower-bud being seen on November 20. The pods commenced setting for cotton on January 15, and the first picking began on February 5, continuing till the middle of May 1903; the plants showed flower-buds, flowers, and ripe cotton at the same time. The plants were cut down for ratoons in the middle of May, as the hard drought was too much for them, and they were beginning to be attacked by leaf disease and scale insects. At the time of cutting down they had many buds, flowers and unripe pods on them.

The plants were attacked for about a fortnight by the American cotton worm, but the pest did not become very serious and was kept in check by making the weeding-gang kill the caterpillars while weeding the cotton. The expenses, for labour only, were as follows, no charge being made for supervision, seeds, rent of land, use of stock, implements, etc:—

	£	s.	d.
Clearing land for ploughing		4	5½
Ploughing		4	4
Lining; cotton planted 3½ feet x 2 feet ...		1	6
Planting and supplying		2	0
Weeding		16	2
Picking		15	0
	£2	3	5½

The produce was weighed at the Botanic Station, and there was a yield of 171·5 ℔. lint, and 556 ℔. seed-cotton. The percentage of lint to seed-cotton was 30·84. The cost per ℔. of lint of above operations was 3*d.* A sample of this cotton taken from the gin was valued by the British Cotton Growing Association at 10*d.* to 12*d.* per ℔., in June 1903. It was reported of good staple and strong, well-prepared, but lacking somewhat in fineness.

The rainfall during the growing period was:—

November, 14·16 inches; December, 2·80 inches: January, 1·15 inches; February, ·91 inches; March, 2·15 inches: April, 1·00 inch; making a total of 22·17 inches.

Dimsdale: This plot was put in really to ascertain whether cotton would be a crop that would pay back in some measure the cost of keeping the land tilled between young lime trees. The results are therefore not as important as the Montpelier plot, and the same details were not kept. The size of plot was about 1 acre, deducting the room occupied by the lime trees. The soil was of a rich, fairly light, volcanic loam, the class of land that bears lime trees well as also pines, tobacco, etc.

The preceding crop had been maize, of which a fine crop had been obtained. The land is exceedingly apt to go back into a thick growth of weed unless kept constantly attended to, so that both preparation and weeding have been much more expensive than at Montpelier. The cost, for labour only, of these operations was as follows (the cotton being planted about the same time as Montpelier):

	£	s.	d.
Ploughing and preparing soil for planting ...	1	12	2½
Weeding	1	12	10½
Planting and supplying		10	7
Picking		14	3
Carting seed-cotton to Botanic Station ..		1	0
	£4	10	11

Yield, 652 lb. of seed-cotton and 181·5 lb. of lint as weighed at the Botanic Station; percentage of lint to seed-cotton, 27·83; cost per lb. of lint of the above operations, 6·01*d.* The cotton was not troubled by insects to any extent, except the red bug which stained it. The staple was long and more silky than the Montpelier cotton, and the seeds were larger and heavier.

MONTSERRAT.

We are indebted to his Honor H. J. Watkins, the Commissioner, for the following information on the Cotton Industry in course of being established at Montserrat:—

Cotton, for many years prior to 1902, had not been grown in Montserrat on commercial lines, but trees of wild cotton, indicative of cultivation in the past, are still to be seen here and there in all parts of the island. The crisis in Lancashire which had been foreseen, but which has, within the past year rapidly approached an acute stage, caused attention to be attracted to the cultivation of cotton in the West Indies and other British colonies, and Montserrat was one of the first, if not the first, island in which experimental cultivation was introduced. The results of the experiments in 1902, on a small scale at the Botanic Station and on a larger scale on several estates, proved eminently satisfactory both as regards quantity and quality. The prices obtained have also been sufficiently remunerative to induce several owners of estates to abandon sugar and place them in cotton, and there is every likelihood of the cultivation being rapidly extended throughout the island on spots where it will flourish.

With regard to the results of the past year,. the following remarks, for most of which I am indebted to Mr. C. Watson, of Dagenham, and Mr. Jordan, may be of interest.

As to the character of the land specially suited to cotton, it has been found that soils of a light gravelly nature are the best adapted to its growth, an average of 1,000 lb. of seed-cotton per acre having been obtained as against a yield of 600 lb. from heavier soils.

Encouragement in the shape of free distribution of good, reliable seed has been given to the owners of suitable lands by the local government and the British Cotton Growing Association of Oldham. Of all the varieties of seed the Sea Island is decidedly the favourite, for it has given the best results both in quantity and in the length of the fibre. There is, moreover, a good demand for long-stapled cotton both in America and in England.

For the crop of 1903-4 it is estimated that nearly 700 acres will be planted. The time for planting is in June and July, or August at the latest. The seeds are planted three to a hole, about 6 to 12 ℔. per acre, in 4-feet rows and 16 inches apart. Some planters advocate 2 feet by 3 feet.

The cost for preparing the land has been from about £1 3*s*., for land previously in bush, to £2 for clearing land in bush.

The period for reaping extends from the middle of November to May and, on an average, 1,000 ℔. of seed-cotton were obtained from an acre. After ginning, the proportion of seed was as 7,163 ℔. of seed to 2,837 ℔. of lint in 10,000 ℔. of seed-cotton or, roughly speaking, 7 to 3. A woman—and picking cotton is work eminently suited for women and children—after a little practice, can pick 40 to 50 ℔. of seed-cotton in a day, that is, an acre in twenty to twenty-five days: in other words, twenty to twenty-five women could pick an acre in a day. Care should be taken to pick the cotton in dry weather. Whether it will be of advantage to ratoon the crop, is a question to be decided by further experience.

The gin used at Dagenham estate is a Macarthy single action gin, of Platt Brothers, Oldham, 40″ roller with self feeder, which cost about £22, and the press is a single box Atlantis self-tramping press made in the United States. Another gin, a Macarthy double action, sent out by the British Cotton Growing Association, has been set up at Trants. About 40 ℔. of lint may, on an average, be obtained in an hour. As the amount ginned has been comparatively small, the cotton has been shipped in bags of about 80 ℔., but a bale would weigh about 550 ℔.

The minimum price obtained has been 10*d*. per ℔., and a maximum of 1*s*. 1½*d*. per ℔. has been obtained. Even higher quotations have been received.

As already said, the question of ratoons will have to be considered in the light of further experience, and one point of consideration will be—how far ratoons are liable to disease. The ratoons have this year been badly attacked by a mite which is supposed to be the same as that which preys on the Hog plum tree. This pest proved so destructive that many acres of ratoons had to be cut down and destroyed. The mite burrows into the leaves which become covered with bumps and turn red later on. The leaves at last curl up, and the plant dies. This disease, it may be noted, has not been detected in any of the wild cotton. A green caterpillar with yellow stripes is another enemy which will have to be reckoned with. Scale insects and the red bug have not, so far, committed ravages of any importance.

Now that the Royal Mail Company has withdrawn the offer of free freight to England, the question of the cost of freight will have to be entertained. No time should be lost by cotton growers to make efforts to have the freight for this new industry placed at reasonable terms.

Coming at a time when the cultivation of muscovado sugar can only be carried on at a loss, the introduction of this industry has been most opportune and may enable the island to tide over, in a measure, a serious crisis in its agricultural history.

ADVANTAGES AND DISADVANTAGES OF A COTTON INDUSTRY AT MONTSERRAT.

Among the advantages are :

(1) A quick return for the outlay.

(2) A good rotation crop for lands long planted in sugar.

(3) The picking and ginning afford employment to many women and children whose husbands and fathers have been obliged to leave the island in search of work elsewhere.

(4) The seed-cotton when picked does not require to be ginned immediately and can be stored.

(5) The comparatively inexpensive machinery which should induce small owners later on to co-operative purchase.

(6) A steady market which will improve rather than decline.

On the other hand, one of the disadvantages according to small owners is that the by-products to the small owner are not so numerous as those of sugar. As one said: 'Cotton ain't molasses, cotton ain't tops, cotton ain't rum, cotton ain't "pickeries" wittles.' Later on, the question of erecting a large central cotton factory in one of the islands, where oil could be expressed and cotton seed purchased from the neighbouring islands, might engage the attention of cotton growers.

Mr. A. J. Jordan, the Agricultural Instructor, furnishes the following hints and information respecting cotton cultivation at Montserrat :—

The best land for the cultivation of cotton in Montserrat has been found to be the lower slopes of the mountains near the sea coast. This land is of a light gravelly nature and well drained. The lighter the land, the better the cotton has grown. For example, of the four estates on the windward side of Montserrat, upon which cotton was grown last season, two have a light gravelly soil and the other two have soil that is more of a sandy loam. On the estates with the lighter soil an average yield of 1,000 ℔. of seed-cotton per acre was reaped : while on the estates with the heavier soils the average yield of seed-cotton was about 600 ℔.

On the leeward side the land upon which cotton was grown, was of a light gravelly nature and the crops averaged about 1,000 ℔. of seed-cotton per acre. The experience of the

past two seasons in Montserrat appear to point to the conclusion that the lighter the soil, provided the necessary plant food is present, the better the cotton thrives.

Most of the land planted in cotton last season was previously in cane, but in one instance some new land was cleared of bush. The bush was first cut and burnt, the debris ranged in lines with a hoe and the cotton seed planted in between the lines. The cost of cultivation was given to me as follows :—

	£	s.	d.
Cutting and burning per acre	1	0	0
Ranging ,, ,, ...		4	0
Planting ,, ,, ...		1	6
Three weedings @ 1*s*. 2*d*. per acre ...		3	6
Picking 1,000 ℔. @ 1*s*. per 100 ℔.		10	0
	£1	19	0

In the case of land planted with cotton after cane, the work was much less. The cane stumps were dug out and the trash ranged in the furrows. The banks were then forked or grubbed over with a subsoil plough and the seeds planted. Three weedings were given during growth. The cost of cultivation was as follows :—

	£	s.	d.
Digging out cane stumps per acre ...		2	6
Ranging trash ,, ,, ...		2	0
Forking banks ,, ,, ...		4	3
Planting seed ,, ,, ...		1	0
Three weedings @ 1*s*. 2*d*. ,, ,, ...		3	6
Picking cotton @ 1*s*. per 100 ℔.		10	0
	£1	3	3

When the plough was used instead of the fork, the cost of ploughing per acre was about 3*s*.

The seeds have in all cases been sown in rows 4 feet apart, but the distance in the rows has varied from 1 foot 4 inches to 2 feet. In the heavier or poorer lands the former distance appears to be the best, but in the case of light and rich soils the latter distance gives the best results. No moulding has been done or appeared to be necessary. The trash protected the plants in their early stages and later they appeared to give sufficient shelter to one another.

The first weeding is generally given as soon as the plants are well above the ground and the second and third weedings at intervals of from two to three weeks, and by the time the last weeding has been given the plants are almost meeting across the rows.

The variety almost exclusively grown has been Sea Island but others have been tried on small plots.

Some five varieties, four Upland and Sea Island were tried upon the heavier lands and the only one that did at all well was 'Hawkins Prolific,' an Upland variety. During

the trial, some heavy rains fell, causing the land to become saturated with water, and the other varieties died.

Last season about 86,000 lb. of seed-cotton were reaped in Montserrat, and the returns have been in every way encouraging. This year about 700 acres have been planted in Sea Island cotton.

BARBADOS.

The following information has been contributed by Mr. J. R. Bovell, F.L.S. F.C.S. :—

Experiments in cotton growing at Barbados were started in September 1902, when some 16 acres were planted on various estates, the greater proportion being grown by Mr. A. Cameron, on the estates belonging to Messrs. T. Daniel & Co., Ltd., and the Rev. Henry Daniel and others, and by Mr. H. E. Thorne, at Sandy Lane.

This year, many more planters and others, having small plots of land, have started growing cotton, the areas varying from a few holes to about 60 acres on one estate, amounting in the aggregate to some 1,200 acres.

Owing to these plots being distributed all over the island, the cotton is being grown on nearly all kinds of soil; from the light sandy loams on the seaboard to the heavy clay lands of the centre of the island.

It is so long since cotton was cultivated in Barbados, that no reliable data are obtainable as to the best methods of tilling the soil, planting the seed, manuring, etc., nor the best distance between the rows, or between the individual plants in the rows. Any information, therefore, given with regard to these questions is to a great extent based on what is considered best in countries where cotton is extensively grown, and what has so far been found successful in Barbados on the small plots grown last year and on the plots now being grown.

SOIL.

Judging by the cotton now growing and from the experiments carried on in other countries, the best soil for cotton appears to be a medium loam. It is stated that on light sandy soils, the yield is usually small; that on clay lands, especially in wet seasons, the plants generally attain a large size, but yield a small amount of lint in proportion to their size. On heavy lands, in favourable seasons, large crops are sometimes obtained, but the plants are liable to disease, and to the attacks of insect pests.

CULTIVATION.

In the Southern States of America, where cotton is the staple crop, much importance does not seem to be attached to deep or annual ploughing. Subsoiling and deep breaking are considered open questions, and the tests, made at the various experiment stations to determine their value, are conflicting and inconclusive. The annual preparation of the land is generally

performed by horse ploughs and cultivators, but once in three years the land is ploughed somewhat deeper.

Deep tillage, therefore, does not seem to be of much importance; so unless cotton follows crops like the sugar-cane or Guinea corn, which bind the soil with their network of fibrous roots, the land need not be ploughed deep. When cotton follows a crop like sweet potatos or yams on medium loam, the tillage effected when these crops are dug out of the soil will probably be sufficient. Where, however, cotton is to follow sugar-canes, particularly ratoons, or where the soil is a heavy clay, it ought to be first thoroughly tilled and then harrowed or hoed over to reduce the surface to a good tilth.

MANURING.

Where cotton is planted after sugar-canes, the land should be manured with farmyard compost supplemented with a suitable chemical fertilizer. Where, however, rotation of crops is practised, it may be more advisable to apply the farmyard manure to the sugar-canes, applying to the cotton sheep manure or a chemical fertilizer, or a sufficient quantity of both. On some experiment plots carried on by the Department of Agriculture to test the best time to plant cotton in Barbados, in a field rented from Waterford, on which rotation crops have been grown and where only sheep manure has been applied at the rate of a ton per acre, the growth of the cotton up to the present time, September 10, leaves nothing to be desired.

TIME TO PLANT.

The cotton planted last year was not sown until September, which is probably too late. This year, as mentioned above, an experiment has been undertaken to ascertain, if possible, the best time to sow the seed by planting plots at different times. A plot of Sea Island cotton was planted at the beginning of June when the rain set in, one at the beginning of July, one at the beginning of August and one at the beginning of September. Careful account is to be kept of the quantity yielded from each plot, and its predisposition to insect attack, etc., noted. It is stated that in the United States, cotton planted early does better than that planted late, as the plants are able to mature their crop before the insect and fungoid pests have caused any appreciable injury.

DISTANCE APART TO PLANT.

In the United States, 4 feet is the usually accepted distance between the rows, and the distance between the plants is within the limits of 8 to 14 inches. Experiments made at the Georgia experiment station for five years to determine the best distance between cotton plants, indicate that on lands so rich or so well fertilized as to produce $1\frac{1}{3}$ bales of lint per acre, the best distance is 4 feet apart between the rows and 1 foot apart in the rows. Numerous experiments on these lines have been conducted on several of the experiment stations in the cotton belt, and the concensus of opinion of the experimenters seems to be in favour of the rows being 4 feet apart and the distance between the rows somewhere between 1 and 2 feet. Assuming

$1\frac{1}{2}$ feet as the best distance between the plants, each plant requires about 6 square feet of surface.

When it was decided to conduct the cotton experiments mentioned above, cane holes had already been dug in the field, in rows $5\frac{1}{2}$ feet apart and $5\frac{1}{2}$ feet between the rows. As the surface of the fields in Barbados is readily washed away by the heavy rains experienced at certain seasons, it is necessary to have these holes dug to prevent the land from 'washing'. This being the case, it was decided to leave the cane holes and to plant two rows of cotton between the rows of caneholes $2\frac{3}{4}$ feet apart in the rows. There are thus four cotton plants to $30\frac{1}{4}$ square feet of surface or just over $7\frac{1}{2}$ square feet of surface to each cotton plant. Judging from the growth of the cotton and from the number of bolls already on the plants of the first plot, they do not seem to be planted too thickly.

DEPTH AND QUANTITY OF SEEDS TO PLANT.

In the experiment referred to above, small holes were dug for the reception of the seed of which four were placed in each hole and covered with soil to the depth of from $\frac{1}{2}$ inch to 1 inch. With the favourable weather conditions, which prevailed, the plantlets commenced to germinate on the fourth day. With the first shower after the end of the tenth day, when all the plants likely to grow had germinated, the non-growing holes were replanted. At this stage where more than two plantlets had grown, the weaker ones were thinned out, the remaining two being allowed to grow for another fortnight, when the weaker plant was cut off.

About 6 ℔. of seed are required to plant an acre.

MOULDING UP.

As soon as the plants were about 8 inches high, they were hilled or moulded up for the first time to prevent their being tossed about by the wind. Later on, when they were about 12 to 16 inches high, they were again moulded up. During the growth of the plants, the land is kept free of weeds by hoeing them up as they appear.

PICKING.

Picking cotton is a somewhat tedious operation at first; but once learnt labourers can, it is said, pick 300 ℔. or more of seed-cotton per day. Cotton should not be picked until the bolls are fully opened. Cotton picked before the bolls are fully ripe is brittle, and is said not to sell for as high a price as that which is allowed to remain on the plants until it is fully matured. Care should be taken to keep the cotton free from portions of the pods, dried leaves, etc.

SUNNING.

After the cotton has been picked, it should be spread in the sun to dry. In the Sea Islands, this is usually done on a platform or 'arbour' made of inch boards, raised a few feet above the ground and some 25 feet, or more, square. Here the sun and air dry the cotton, preventing it from heating which it is liable to do when stored in bulk, and it is also thought to

cause the lint to absorb some of the oil of the seed, which adds to the silky lustre of the fibre. In any case before the cotton is delivered at the factory it should be as *dry* as possible.

INSECT PESTS.

So far only two species of caterpillar and a flea beetle have attacked the cotton grown this year. Of the two caterpillars one eats the leaves and the other cuts off the young plants just above the surface of the ground. The first is readily controlled by dusting the leaves of the plants with a mixture of one part of Paris green to 99 parts of sifted lime. The cut worm has done so little damage that, beyond replanting the holes destroyed, there is no necessity to take further action in the matter. The flea beetle has so far been kept in check by the larvae of two species of lady-bird.

CARRIACOU.

The following report on the present condition of the Cotton Industry at Carriacou has been communicated by direction of Sir Robert B. Llewellyn, K.C.M.G. It was prepared by Mr. McNeill, Agricultural Instructor at Grenada, who visited Carriacou in February 1903, for the purpose, on the suggestion of the Commissioner of Agriculture:—

There are at present seven gins working in the island—two at Hillsborough, owned by Messrs. Patterson and Sylvester Joseph; one at Dover belonging to Mr. Mitchel Cox; two at Grand Bay, owners, Messrs. Belmar & Drummond; one owned by Mr. James Henry, and one at Harvey Vale belonging to Mrs. Gordon. All the gins are of the same pattern—H. S. Emery's patent saw gin, makers: W. J. & C. T. Burgess, late Burgess & Key, Brentwood, England. Four of these are driven by steam and three by wind power. The cost of one of these (twenty-nine saws) landed in Grenada was £60 8*s*. 4*d*. Prices vary according to size, but the owners as a rule could not state the prices. The price of an engine and boiler imported from England two years ago was £135 13*s*. 3*d*. The best engine in the island, belonging to Mr. Mitchell Cox, was imported from America about a year ago—'The Clipper' (makers: The Blymer Iron Works Co., Cincinnati, Ohio). The price was less than that stated above but exact figures were not given. It is fitted with gear for pumping water and for pressing the cotton.

Gins of thirty-five saws driven by steam are said to clean an average of six bales in a day of ten hours. Those driven by wind do not work so steadily and average less in a day. A good deal of foreign matter, pieces of straw, etc., pass through the machines with the lint, owing to the saws and other parts of the machinery getting out of order, and this causes a slight reduction in the value of the cotton.

The kind of press in general use in the island is the Victoria screw press. The first cost of one of these was £85 13*s*.; landed in Grenada, £103 4*s*. It requires six men to press one bale of cotton.

The owners of gins charge 7*s.* for ginning a bale of cotton (300-310 ℔.). Cartage from field to mill, pressing, baling, and cartage to port are included. The owners of the cotton provide cloth, rope, and twine for baling. All the gins, with the exception of one, are conveniently situated close to the shore for shipping the produce. Formerly the price charged for ginning was $3 per bale. With the introduction of steam engines the price was reduced to 9*s.* and subsequently to the present figure.

The price paid, locally, for raw cotton is 8*s.* 4*d.* per 100 ℔. or 1*d.* per ℔.

KINDS OF COTTON.

There are at least two distinct kinds of cotton grown in the island locally known as Marie-galante and Sea Island cotton, specimens of which are forwarded with this report. The Marie-galante is more robust in habit and bears larger capsules. This is the kind generally grown. Plants of the Sea Island cotton are usually found growing among the Marie-galante, but many of the planters are in the habit of cutting them down and supplying the vacancies with the favourite kind. In travelling through the island one hears of silk cotton as well as Sea Island cotton, but I understand from authorities on the subject that they are synonymous terms.

With regard to the proportion in weight between seed and lint, the current opinion is that Marie-galante gives one-third its weight in lint, whereas it takes about 1,200 ℔. of Sea Island cotton to give a bale of the usual weight.

CULTIVATION.

Most of the cotton on the island is grown on the 'Metaire' system. The planting season is from May to August, but with the method practised of allowing the plants to remain in the ground for an indefinite period, seeds are only sown when new fields are to be planted or supplies made. There is no regular method of replanting exhausted fields. The distance between the plants varies from 2½ to 4 or 5 feet. Three to 4 feet is the average distance. As a rule each labourer gauges his own distance, which accounts for the variation in that respect. In planting, the surface of the ground is simply chopped up with the hoe where the seeds are to be sown, and about a dozen put in; these are thinned down to three or four after they commence to grow. The old plants are cut back each year to within a foot of the ground. Corn is planted between the rows in May before the cotton is cut back, and it is generally some distance above the ground before the pruning of the cotton takes place. The corn is cleared off the land in August and September. The average yield is said to be between 15 and 20 barrels per acre, worth from 4*s.* to 8*s.* per barrel according to the time of the year. Peas are generally planted between every fifth or sixth row of cotton, sometimes closer and sometimes wider. Cassava and ochros are also occasionally planted between the rows.

Three weedings are annually given by those working on the 'Metaire' system. The first is given in June, the time for

the others is regulated by the rate at which the weeds grow. No other tillage is given and no manure is applied.

PICKING.

Small pickings are sometimes made in December, but the bulk of the picking is done in March and April. Women and sometimes children are employed for this work. The average daily picking for one person is 30 ℔. to 40 ℔., for which 6*d.* is paid. Cost of picking averages about $\frac{1}{2}$*d.* for every pound of lint.

YIELD.

The average yield of the island is said to be much less than a bale per acre. It is stated to be as low as $\frac{1}{2}$ bale per acre in many places. The following is a statement by Mr. A. H. Stiell with regard to the yield and other important points about cotton: 'When I was manager of Grand Bay and Mount Pleasant estates. I measured off 18 acres which I planted with picked seeds of Marie-galante—the seeds were hand picked, steeped in a bucket of water and all the light ones which floated thrown away. The yield from this piece was 20 bales (310 ℔. each) of clean cotton. This kind of cotton takes 900 ℔. gross to give 300 ℔. net. The Marie-galante being of a very thick texture can remain on the trees when open for several days, and if fallen, can be picked up without earth adhering. The Sea Island cotton takes about 1,200 ℔. to give a bale of 310 ℔. It is flimsy and easily taken away by the winds, therefore more attention has to be paid to picking soon after opening. It gets spoilt when it falls to the ground. During March and April the bulk of cotton is reaped from the valleys. Hills give the bulk in February. Planting under the "Metaire" system is done from May to August. Those planted late in the season do not grow so tall as those planted in May and June, which is considered an advantage.'

The cotton is taken from the field in ordinary bags, ginned, weighed and baled. It is exported to England through agents in St. George's. Freight, commission, dock dues, etc., amount to about 3*d.* per ℔. The seed is also sent to England and was recently fetching about £6 per ton.

There is no doubt that a great improvement could be made in this industry and a larger yield per acre obtained by (1) planting improved varieties, (2) better tillage, and (3) manuring. With regard to improvement by introducing special kinds of seed, I beg to quote a paragraph in reference to this matter from a letter written by the late James Paterson, dated June 4, 1895, who was one of the principal planters in the island, to the Curator of the Botanic Station: 'We grow cotton year after year from the same plants; on two occasions I imported Egyptian seeds and our late Governor, Sir W. Hely-Hutchinson, imported some cotton seeds which he sent to the Police Magistrate for distribution among certain planters. These importations have certainly improved the quality of the cotton in some districts.'

Tillage, as already seen, is practically restricted to the stirring of the surface soil three times in the year when the

land is being weeded. The kind of manure best suited for the cultivation of cotton in Carriacou is a question that has yet to be solved.

I venture to suggest that this is an opportune moment, when an effort is being made to establish a peasant proprietary on the island, for starting a cotton experiment station among the proposed peasant lots on Beausejour estate. The 'Metaire' system is responsible to a great degree for the comparatively small yield of the island, as the labourer gets his crop with as little expenditure of energy as he can. Under this system there is little hope for improvement in the people's method of cultivation. An experiment station will prove useful in many ways: the best kinds of cotton could be tested and distributed among the people, good tillage practised and results compared with those from the ordinary cultivation. Various methods of planting and pruning could be tried and manurial experiments carried out, besides being generally a model plot for the surrounding peasantry.

I, therefore, recommend that an ordinary sized lot, 4 or 5 acres, in a convenient place on Beausejour estate be reserved for this special purpose, under the control of the Agricultural Department, and a small subsidy be given to one of the best planters in the island for looking after it and carrying out the instructions issued by the Agricultural Department for its working. Cotton cultivation, on the whole, is simple and inexpensive, and the returns from a 4- or 5-acre lot should go a long way towards paying the expenses incurred in a scheme of the kind.

The outlook for the current year's crop is considered good.

THE AGRICULTURAL CHEMISTRY OF COTTON.

In this article, compiled by Professor J. P. d'Albuquerque, it is proposed to describe briefly the composition of the cotton plant with reference to the uses to which the planter and the manufacturer may respectively put its several parts, to the draft on the land, entailed by its cultivation and to the manuring of cotton. With one or two exceptions what follows has been abstracted from Bulletin No. 33* of the United States Department of Agriculture issued in 1896.

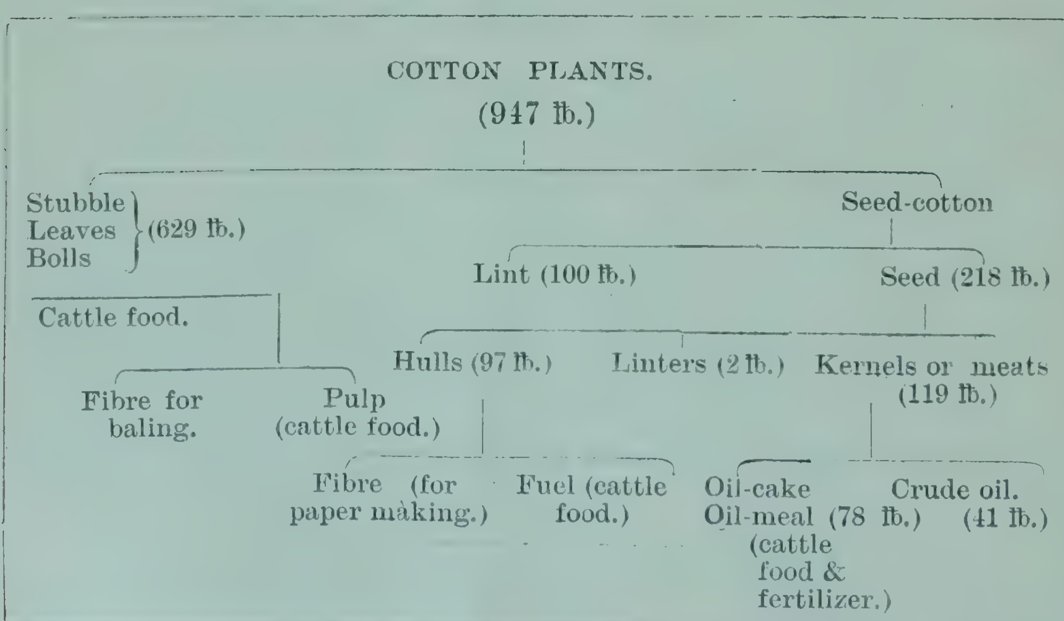
The Cotton Plant: U.S. Department of Agriculture, Office of Experiment Stations.

McBride gives the following as the proportions to 100 lb. of lint of the different parts of the plant, together with the more important fertilizing ingredients found in each :—

Pounds per 100 lb. of Lint.		Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.
Roots, 83; Stems, 219; Leaves, 192; Bolls, 135	...	13·55	5·30	10·05	11·86	3·47
Seed, 218	...	6·82	2·77	2·55	·55	1·20
Lint, 100	...	·34	·10	·46	·19	·08

The above statement is instructive as showing that, if everything except the seed is returned directly or indirectly to the land, this plant is by no means exhausting; and if, as is suggested in what follows, the seed is crushed and the meal returned to the planter for use as a cattle food, the growth of cotton would be one of the least exhausting crops that it would be possible to raise.

The following diagram exhibits roughly the uses to which the different parts of the plant are put:—



ROOTS, STEMS, LEAVES AND BOLLS.

The following analyses indicate the proximate constituents of the stems, leaves and bolls and will serve to give an idea of their feeding value :—

Composition per cent.			
	Stems.	Leaves.	Bolls.
Water	10·00	10·01	11·92
Fat	1·83	6·05	1·38
Protein (albuminoids, etc.)* ...	9·54	21·64	6·96
Nitrogen free extract (carbohydrates, etc.)	32·63	36·82	39·90
Fibre	40·77	12·57	32·50
Ash†	5·23	12·87	7·34
*Containing nitrogen	1·46	3·21	1·08
†Containing phosphoric acid ...	·59	1·19	·48
†Containing potash	1·41	1·80	2·66

The stems, leaves and bolls are used as cattle food, and cattle feed readily on cotton at all stages of its growth.

Experiments have been succesfully made with a view of extracting fibre in the cotton field from the stems and roots, to be afterwards made into bagging for cotton bales or manufactured into carpets. The residue forms a coarse-grained pulp, which can be fed to cattle when fresh, but would not keep. When dealt with in this manner, to every bale of cotton the stubble would yield 1,440 ℔. coarse fodder and 270 ℔. fibre, which would be sufficient to cover 20 bales of cotton.

LINT.

Cotton in its crude state is not a pure cellulose but contains a number of other ingredients amounting to about 16 per cent. Its proximate composition is as follows :—

Water	6·74
Fat	·61
Protein*	1·5
Nitrogen free extract ...	5·79
Fibre	83·71
Ash†	1·65

*Containing	nitrogen ...	·24
† ,,	phosphoric acid	·10
† ,,	potash ...	·46

From the above it is evident that it removes exceedingly small amounts of the fertilizing ingredients of the soil.

COTTON SEED AND COTTON SEED OIL.

The seed as it issues from the gin has still attached to it a small quantity of cotton; and the kernel or meat is covered with a hard envelope, the hull. The subsequent operations are the storage of the seed, the removal of the residue of cotton, called linters, the hulling, etc., separation of the kernels from the hulls, and the extraction of the crude oil, leaving the cotton seed meal.

Cotton seed is bulky, 1 ton occupying 38 cubic feet of space; it is also liable to deterioration on keeping. It is therefore advisable to deal with the seed as rapidly as possible.

The following is a brief outline of the manufacture of cotton seed oil and its by-products:—

The cotton seed is shovelled from the carts into a bucket elevator, whence by a screw conveyer it is carried to chutes and discharged into storage rooms.

From the storage rooms it is carried, as required, by elevators and conveyers to the revolving 'boll screen,' which retains bolls and other large impurities and allows the seed to pass through; it is similarly conveyed to a fine revolving screen, which retains the seed and allows sand to pass; hence it is conveyed to the blower, which expels fine dust and blows the seed over magnetic plates, the purpose of which is to retain fragments of iron brought from the gin. These cleaning operations reduce the weight of the seed by 6 per cent.

The fragments of cotton still adhering to the seed, if not removed, would absorb some of the oil expressed in the subsequent operations and prevent its effectual extraction. The next process is to convey automically the clean seed to the 'linters,' which is a large saw gin capable of working up 16 to 24 tons in twenty-four hours. This removes the short fibre, which, taking its name from the special gin, is called 'linters' and is used to make hats and cheap cloth, and is sold at a lower price than lint.

A conveyer now carries the seed to the 'huller,' which consists of two concentric cylinders, the outer one stationary, the inner one revolving 850 times a minute and each provided with knives which cut the seed and allow the meats or kernels to drop out.

The meats and hulls pass to a revolving screw where the former drop through, the hulls being retained, and afterwards removed to be used either as fuel, as bran for cattle food, or manufactured into fibre for paper.

In the United States, in districts where coal sells at $3·50 per ton, the hulls are valued at 80 cents per ton as fuel.

The following is a proximate analysis of the hulls:—

Water	11·36
Fat	2·22
Protein (albuminoids)* ...	4·18
Nitrogen free extract (carbohydrates)	34·19
Fibre	45·32
Ash†	2·73
*Containing nitrogen ...	·69
† ,, phosphoric acid	·25
† ,, potash ...	1·02

This analysis at once indicates the approximate value of the hull bran as a food, especially when mixed with cotton seed meal. It also indicates the desirability of returning this material directly to the land, or indirectly in the manurial residue from cattle. in order to prevent the loss of the fertilizing ingredients.

The meats or kernels pass between a series of heavy chilled iron rollers, which mash them into thin flakes and crush the oil cells, and are then conveyed to the heaters which are cast iron, steam-jacketted kettles provided with stirrers: here the meats are heated for twenty to thirty minutes, the time being decided by an experienced workman; the water is thus driven off and the oil rendered more fluid. The meats are then shaped into cakes in the 'former,' and either wrapped in camels' hair cloth, or placed on shallow steel frames, and taken to the hydraulic press, where they are subjected to a pressure of 3,000 to 4,000 ℔. to the square inch. The crude oil runs from the press to the settling tank and the cake, solid as board, is stripped, weighed and stacked to dry, afterwards being broken into lumps and ground into cotton seed meal.

The following is an average analysis of samples of cotton seed meal:—

COTTON SEED MEAL.

Water	7·80
Fat	9·31
Protein (albuminoids, etc.)*	42·00
Nitrogen free extract (carbohydrates, etc.)	27·83
Fibre	7·18
Ash†	5·88
*Containing nitrogen	6·72
† ,, phosphoric acid	2·42
† ,, potash	1·95

Cotton seed meal is one of the richest and most valuable cattle food-stuffs. Its food value exceeds that of corn meal by 62 per cent. and wheat meal by 67 per cent.

It is also a valuable manure chiefly on account of its richness in nitrogen, but it is far more economical to feed it to cattle, when 80 per cent. of its manurial value is recovered in the dung.

The yield of crude oil amounts to about 45 gallons per ton of seed. It is allowed to remain some hours in the oil-settling tank and the sediment called 'foots' is re-heated and re-pressed and the residue sold as soap stock. The oil is drawn off and barrelled and exported as crude oil, or as 'refined'.

REFINING OF COTTON SEED OIL.

The crude oil is heated, agitated by blowing air through it, and treated with caustic soda to coagulate the impurities, which sink to the bottom of the tank.

The oil drawn off, washed with water, again drawn off and passed through the filter press, constitutes the 'summer yellow' of commerce, which is employed in the manufacture of margarine and butterine and in the tempering of steel.

From 'summer yellow,' if artificially cooled, separates solid stearin; from this, cotton seed 'salad oil' may be separated by pressure, the stearin being employed in the manufacture of butterine.

'Summer yellow,' by treatment with fuller's earth or other bleaching agent, is converted into 'summer white,' and this by cold and pressure is separated into white stearin (solid) used in the manufacture of 'compound lard' and 'winter white,' a colourless oil used as a fuel for miners' lamps and for the making of medicinal 'compounds.'

CENTRAL OIL FACTORIES IN THE UNITED STATES.

A common arrangement in the cotton-growing States is for the central mills to offer 1 ton of meal for 2 tons of seed including freight both ways. It is claimed that this arrangement is profitable to both parties, as the meal contains substantially all the fertilizing ingredients of the seed and is in a form far more suitable for cattle food. For these reasons it would appear to be an arrangement well suited to the needs of the West Indian planters who grow cotton.

THE FEEDING VALUE OF COTTON SEED PRODUCTS.

Under this head a large amount of information is brought together on the results of feeding experiments with cotton seed produced in the United States and in England.

Raw cotton seed cannot be successfully fed to animals, as the lint and dust render it injurious and it is too rich. It appears to be especially injurious to pigs.

Cotton seed meal and cotton seed meal mixed with hulls are employed in enormous quantities in the United States in the fattening of cattle, and can be fed to cattle, sheep, horses, mules and poultry. The experiments conclusively prove the value both of the meal, and meal mixed with hulls.

As an instance of the kind of results obtained at Woburn, England, it was found that with fattening bullocks a mixture of equal parts of decorticated cotton seed cake (cotton seed meal) and maize meal produced a larger increase in live weight and at less cost than linseed cake.

The cotton seed meal in 'digestibility' experiments proved to be highly digestible; but, as might be expected, the digestibility of the hulls was low. There can be no doubt that cotton seed meal, mixed with hulls or molasses and fed in addition to the usual green fodders, would form a valuable aid in rendering the sugar plantations self-supporting. With such foods produced at home, there is no reason why any 'oil meal' should be purchased from abroad.

C. P. Brooks, in his work on cotton, estimates as follows the cost of the erection of the plant for the manufacture of cotton seed oil and its by-products :—

Capacity for twenty-four hours in tons.	Buildings including oil mill, boiler, seed and meal houses.	Land and railroad sidetrack, and water supply.	Press-room machinery f. o. b. factory.	All other machinery in oil mill to make crude oil.	Freight and erection.	Total for oil mill boilers, seed and meal house.	Refinery, including buildings and all machinery.	Total for oil mill, and refinery.	Ginnery, 6-stand gins, and cotton warehouse.	Total for oil mill, ginnery and refinery.
	$	$	$	$	$	$	$	$	$	$
10 to 15	5,000	1,000	4,500	5,000	2,000	17,500				
20 to 30	10,000	2,000	6,400	8,500	4,500	31,400	11,600	43,000	15,000	58,000

THE MANURING OF COTTON.

Dr. White, in the United States Bulletin on cotton, formulates the following general conclusions, which, though referring to the cotton-growing States of America, in the absence of any special local experiments, will offer valuable suggestions as to the lines upon which planters should proceed in the West Indies :—

GENERAL CONCLUSIONS.

In reviewing the results of the experiments conducted at, or under the auspices of, the experiment stations, and taking into account the general experience of successful cotton

growers, certain general conclusions on the subject of the fertilization of cotton may be accepted as tentatively established.

(1) Cotton is a plant which responds promptly, liberally and profitably to judicious fertilization.

(2) By judicious fertilization the maturity of the crop may be hastened, and the period of growth, from germination to fruiting, so shortened as to increase materially the climatic area, within which cotton may be profitably grown.

(3) As is the case with most other crops, the profit from manuring cotton with concentrated fertilizers is much enhanced by antecedent proper preparation of the soil. It pays to bring cotton lands up to a condition of good 'tilth' by mechanical treatment, and especially by incorporating liberal quantities of organic matter. Upon lands in such condition fertilizers of all kinds yield more profit, either from small or large applications, than upon lands not so treated.

(4) Renovating crops, and especially the cow pea, furnish an efficient and economical method of bringing cotton lands into condition to respond most liberally and profitably to the application of concentrated manures under cotton. The most profitable plan of employing the cow pea for this purpose on cotton is to gather the peas at maturity, cut the vines for hay, and turn under the stubble, along with the manure resulting from feeding the hay to stock and cattle.

(5) Barnyard manure and similar bulky manures are more efficient and profitable as soil renovators than as specific fertilizers for cotton. They should be broadcast liberally and used rather as soil improvers than as immediate fertilizers. The same is probably true of cotton seed, except where the price to be had for the seed at cotton-oil mills justifies the exchange of seed for cotton seed meal, to be used as the source of nitrogen in a concentrated manure. If, however, only small quantities of such manures are to be had, and it is desired to use them as direct fertilizers, it is more profitable to compost with acid phosphate (preferably containing a small percentage of potash) than to use them alone. It is more profitable to compost directly in the drill at time of planting than in heaps previously.

(6) Cotton may wisely be assigned a place in a judicious rotation system. Upon lands devoted to staple crops a three-years' rotation—small grain, corn (with peas), cotton—is judicious. Each crop in the rotation should be appropriately fertilized. It is in evidence that the cumulative effects of such manuring upon the succeeding crops are marked.

(7) Upon the great majority of the soils of the cotton-growing States it is advisable and profitable to use, as a concentrated fertilizer, a 'complete manure,' that is, one containing soluble phosphoric acid, available potash and available nitrogen, rather than a manure containing only one or two of these ingredients. Nitrogen, however, may probably advantageously be omitted from the concentrated fertilizer, in whole or in part, when the soil has previously been liberally supplied with this ingredient, through barnyard manure, green manuring, etc.

(8) 'Soluble' phosphates are very much to be preferred in the fertilizer for cotton to those which are not soluble.

(9) There is no great difference, if any, in the agricultural value and profit when used in the fertilizer for cotton, of the various soluble potash salts to be had in commerce, except proportionately to the price and content of actual potash.

(10) Of the nitrogen compounds available for use in fertilizers, the organic forms (vegetable and animal) are perhaps best suited to cotton, if one form alone be used, although nitrate of soda is probably nearly, if not quite, of equal value. Further experiments are needed to determine the efficiency of mixing various nitrogen compounds in different proportions.

(11) The most judicious proportions of soluble phosphoric acid, potash and nitrogen in a complete fertilizer for cotton can not be said to have been as yet determined with entire accuracy. Those suggested by Georgia—nitrogen 1, potash 1, phosphoric acid $3\frac{1}{2}$—and by South Carolina—nitrogen 1, potash $\frac{3}{4}$, phosphoric acid $2\frac{1}{4}$—perhaps approximate to reasonable accuracy. In the light of present information, perhaps, nitrogen 1, potash 1, phosphoric acid $2\frac{3}{4}$ or 3 would not be injudicious proportions for general use.

(12) The amount of concentrated fertilizer which may profitably be used per acre varies widely with the nature and condition of the soil, the seasons and other circumstances. For an average soil, in fairly good condition, perhaps the maximum amounts indicated by Georgia (nitrogen, 20 ℔.; potash, 20 ℔.; phosphoric acid, 70 ℔.), or by South Carolina (nitrogen, 20 ℔.; potash, 15 ℔.; phosphoric acid, 50 ℔.), or an approximate mean of the two, would be the maximum limit of profitable application. The actual weight of the complete fertilizer furnishing these quantities would, of course, vary with the percentage composition in nitrogen, potash and phosphoric acid of the materials used to make the fertilizer. If the commercial 'ammoniated' fertilizer 'or other concentrated manure' intended for use under cotton, should be compounded (as it might very well be, and in some cases is) to analyse approximately:—

	Per cent.
Soluble (available) phosphoric acid ...	9
Potash	3
Nitrogen	3

then 700 ℔. per acre of such a fertilizer would be approximately the maximum amount that could judiciously and profitably be used under ordinary circumstances, upon soil in good condition.

(13) The concentrated fertilizer should be applied in the drill (not broadcast) at a depth of not more than 3 inches, and well mixed with the soil.

(14) All things considered, it is perhaps best, in most cases, to apply all the concentrated fertilizer in one application at time of planting. With lands in superior condition, however, or where large quantities of fertilizers are used, it is probably profitable to apply half at planting, and half at the second ploughing.

WEST INDIAN IMPORTS AND COTTON SEED PRODUCTS.

The tables of imports at the end of this article, taken from the Blue-books published in 1903, will serve to draw attention to the large quantities of feeding-stuffs, oleomargarine, cotton-seed oil and other substances which, at present imported, might in the future be manufactured locally from cotton seed grown in these islands.

In Barbados alone the records show an importation in 1902-3 of over 3,000,000 ℔. of 'oil-meals.' If locally produced cotton seed meal were substituted for this, the seed from upwards of 12,000 acres of land under cotton would be required. A large proportion of the expressed oil could be consumed locally in the forms of cooking oil, oleomargarine, etc., leaving the balance to be exported.

The cost of a factory capable of handling this amount of cotton seed, judging from Brooks' estimates, would amount to about $70,000.

CONCLUDING REMARKS.

Cotton is a crop that supplies not only marketable commodities, namely, cotton and cotton seed oil, for which there exists a large demand, but also residues of considerable value as cattle foodstuffs.

Provided the planter who raises the cotton obtains and utilizes the residues on the plantation, cotton is a crop that entails a very small mineral and nitrogenous draft on the land.

In consequence, however, of the processes that occur in all well-tilled soils, the growth of cotton is attended by a loss of humus, and it is essential, if the fertility of the soil is to be maintained, that this loss should be provided for, not only by the utilization on the plantation of the stubble, leaves and bolls of the plants, but also by the application of farmyard manure or the turning under of a growth of leguminous green dressing, before the sowing of the cotton.

It is earnestly recommended that the cotton seed should not be sold off the land except an equivalent amount of cotton seed meal is received in return, to be utilized on the plantation. Otherwise soil exhaustion will have to be provided against by applications of artificial manure and larger applications of farmyard manure.

Where it is considered desirable to employ artificial manures in order to increase the crop or shorten the period of its growth, from the experiments carried on in the cotton-growing States of America, it would appear that an application per acre should contain 20 ℔. of nitrogen, 20 ℔. of potash and 60 ℔. of soluble phosphoric acid. It is probable that experiments in cotton-growing on West Indian lands will modify this recommendation for these islands.

There is a considerable local consumption of oil-meals as cattle food and of cotton seed oil and its products. These might well be supplied by locally grown cotton, thus helping to render estates self-supporting.

An area of 6,000 acres of cotton would suffice to keep a small central oil factory employed for 100 days. Provided the area under cotton in a small island like Barbados did not fall below that amount, the erection of a central oil factory would be advisable, in order to avoid exporting the seed, and to obtain locally the benefit of the by-products. The seed might be exchanged for cotton seed meal plus a reasonable money allowance for cartage each way, or the planter might pay so much per ton for the manufacture, and receive an amount of cotton seed meal equivalent to his seed plus a proportionate share of the proceeds of oil sales.

RESULTS OF RECENT ANALYSES OF IMPORTED AND OTHER FEEDING STUFFS AT BARBADOS.

(J. P. D'ALBUQUERQUE.)

FOOD STUFFS.	Number of Samples.	Moisture.	Oil.	Albuminoids.	Mucilage, Starch, etc.	Indigestible Fibre.	Ash.	Nitrogen.	Phosphoric Anhydride.	Potash.	Sand.	Value in Units.	Albuminoids ratio 1 to:—
Oats ... (imported) ...	2	10·14	6·33	12·91	57·27	9·03	4·32	2·06	2·06	0·49	2·35	105	5·6
Maize ... (Barbados)	1	12·43	4·83	11·81	67·61	1·70	1·62	1·89	1·31	0·42	0·31	109	6·7
Maize ... (American) (imported) ...	3	11·17	4·17	9·48	72·18	1·68	1·32	1·52	1·04	0·37	0·31	107	8·7
Maize meal .. ... (imported) ...	11	9·66	3·06	9·31	76·22	0·82	0·93	1·49	0·91	0·33	0·28	107	9·2
Guinea corn (Barbados)	1	12·18	3·10	7·88	67·07	2·52	7·25	1·26	1·37	0·38	0·62	95	9·5
Cotton seed meal ... (imported) ...	2	7·80	9·31	42·00	27·83	7·18	5·88	6·72	2·42	1·95	0·13	156	1·2
Linseed oil meal ... (imported) ...	33	9·57	7·38	34·16	35·75	8·04	5·10	5·47	2·01	1·37	0·73	140	1·6
Inferior linseed oil meal (imported) ...	7	9·34	7·26	25·56	41·94	9·45	6·45	4·09	1·76	1·33	2·09	124	2·3
Pollard ... ... (imported) ...	15	10·71	4·97	17·65	52·00	9·06	5·61	2·82	2·53	1·13	1·30	108	3·7

TABLE OF IMPORTS. 1902-1903.

IMPORT.	Barbados.				Grenada.				St. Vincent.			
	Total Import.	Total Value.			Total Import.	Total Value.			Total Import.	Total Value.		
		£	s.	d.		£	s.	d.		£	s.	d.
Butter	229,931 lb.	11,496	11	0	$26,862\frac{1}{2}$ lb.	1,623	13	0	26,187 lb.	1,431	6	1
Oleomargarines	368,231 lb.	7,671	9	7	169,820 lb.	3,608	4	7	11,120 lb.	227	6	0
Lard	...	...			92,432 lb.	1,820	15	0	12,665 lb.	200	8	2
Cotton seed oil	...	8,889	5	3	9,029 galls.	1,221	18	1	1,574 galls.	201	16	2
Lard oil	...	...			$399\frac{11}{12}$ galls.	91	10	7	158 galls.	16	14	9
Olive oil	...	...			10,209 galls.	2,430	9	5	$1,051\frac{1}{2}$ galls.	305	13	1
Other oils	..	4,132	1	7	$1,310\frac{7}{8}$ galls.	260	7	8	$1,614\frac{1}{2}$ galls.	274	3	11
Bran	2,588,233 lb.	5,823	10	1	...	416	7	6	...	185	8	9
Oats...	4,302,568 bshls.	13,983	6	11	24,931 bshls.	3,954	4	6	1,984 bshls.	312	18	0
Maize	3,187,241 lb.	7,171	5	10	$1,673\frac{1}{2}$ bshls.	318	10	1	$1,222\frac{3}{4}$ bshls.	267	6	0
Corn meal	31,742 brls.	16,664	11	7	...	...			...	...		
Oil meals	3,087,227 lb.	9,261	13	7	...	...			117.625	497	19	1
Other meals	69,848 lb.	436	11	0	114,407 lb.	635	3	6	908 brls.	686	19	10

TABLE OF IMPORTS. 1902-1903. *(Concluded.)*

IMPORT.	Leeward Islands.		Jamaica.		Trinidad.	
	Total Import.	Total Value.	Total Import.	Total Value.	Total Import.	Total Value.
		£		£ s d.		£
Butter	68,592 ℔.	3,558	368,508½ ℔.	13,819 1 4	567,846 ℔.	24.864
Oleomargarines	175,715 ℔.	3,906	380,679 ℔.	7,137 14 7	226,510 ℔.	4,403
Lard	129,439 ℔.	2,149	98,314 ℔.	1,638 11 4	1,381,636 ℔.	24,154
Cotton seed oil	...	...	82,362 galls.	5,662 9 0	...	...
Lard oil	...	...	...	...	1,938 galls.	331
Olive oil	11,162 galls.	1,490	484 galls.	181 13 6	40,081 galls.	9,079
Other oils	8,071 galls.	1,037	...	...	...	...
Bran	...	...	...	490 13 1	...	3,391
Oats...	1,321 bshls.	205	50,342¼ bshls.	5,663 9 5	182,951 bshls.	21,750
Maize	...	...	208,463¾ bshls.	23,452 3 5	45,930 bshls.	6,648
Corn meal	19,396 brls.	13,160	26,851 brls.	16,110 18 6	...	...
Oil meals	1,531,105 ℔.	5,639	...	...	9,638 brls.	6,368
Other meals	...	...	...	...	4,344,010 ℔.	13,908

FUNGOID DISEASES OF COTTON.

BY L. LEWTON-BRAIN, B.A., F.L.S.,

Mycologist and Agricultural Lecturer on the staff of the Imperial Department of Agriculture.

Although up to the present very few fungoid diseases have appeared on cultivated cotton in the West Indies, yet it is possible that, as the area under cotton is increased, other diseases will appear, and that they will assume a greater importance. The following description of the chief fungoid diseases of cotton, that have been noted in the United States and elsewhere, is merely a preliminary account, intended to inform cotton planters what diseases to expect, how to recognize them when they appear, and what treatment to adopt in dealing with them.

The point to which I would draw special attention is the need for constant watchfulness, so that any disease will be noticed when it first appears. Unless this happens, remedial measures are not likely to prove of any use. Too often a disease is not noticed until a whole field is badly affected, and then the only recommendation that can be made is that the whole crop on the field should be cut back, and all the parts cut off be destroyed. If diseases, especially those of the leaf and fruit, prove serious on an estate, it will probably pay to spray the cotton, with Bordeaux mixture or some other fungicide, as the young leaves and fruits are growing and before any signs of disease have appeared. This spraying should then be repeated at intervals throughout the season. In this way serious outbreaks of these diseases will be prevented.

Another point that should be noted is that weak and unhealthy plants are far more liable to be attacked by disease than healthy ones. Some diseases of cotton are entirely due to unfavourable conditions, and in every case unfavourable conditions favour both the start and the progress of the disease. Care should therefore be taken that the situation, the soil, the cultivation, etc. are such as are favourable to the growth of the cotton plants and consequently unfavourable to the diseases.

ROOT GALL*.

This, although not a fungoid disease, may be described here, in order to render the account of known diseases of cotton as complete as possible.

The disease is due to the attack of a minute parasitic worm (*Heterodera radicicola*), which burrows into the tissues of the roots and by its presence there causes abnormal thickenings of the root, known as galls. The knotted appearance of the roots is very characteristic of this disease. The worms are very

*G. F. Atkinson—'Some Diseases of Cotton.' Alabama College Station, Bulletin, No. 41.

Atkinson in 'The Cotton Plant' (p. 311). U.S. Department of Agriculture, Office of Experiment Stations, Bulletin No. 33.

minute, almost microscopic, in size, being just visible to the naked eye.

The damage caused by the worm itself does not appear to be serious; by causing the swellings on the roots, it diverts a large amount of food that would otherwise be utilized in building up the normal tissues of the plant. It thus weakens the plant and, especially, lessens the formation of fruit. The most serious point about this disease is that, as the young worms enter or leave the root, they produce wounds, which afford easy points of entry for the spores and mycelium of certain fungi causing very serious root diseases, especially that known as 'wilt' or 'frenching.'

FIG. 1, Root Galls.
[From *The Cotton Plant.*]

The eggs of the worm hatch out to a small larval form. The larva is a minute, eel-like creature, rather blunter at the head end than the other. Projecting slightly from the mouth, at the head end, is a tiny, slender spear, which the larva can move backwards and forwards. The larva when hatched is enclosed in the tissues of the root gall; it escapes from these either on the decay of the roots, or by forcing a path of escape by means of its spear. It now proceeds to enter a fresh, uninjured root, by cutting its way in with the spear. Once inside the root, it soon becomes stationary, sucks up the sap of the plant, and, by the irritation it sets up, causes an extra flow of food supply to the part attacked and so produces the galls. The worm itself soon loses its eel-like form, swells up and becomes transformed into a gourd-shaped bladder or cyst, in which state the female remains for the rest of her life. A female worm will produce 200 to 300 eggs, and, under favourable conditions, these will hatch and pass through all the stages to the mature female, with more eggs, in about

a month. It will be seen, therefore, that this parasite possesses considerable power of multiplication.

ROOT ROT*.

This disease is due to the attack of a soil-inhabiting fungus which attacks the roots of cotton, and some other cultivated plants. No reproductive organs of the fungus have yet been discovered on the attacked plants; nor has it been found possible, as yet, to obtain them in artificial cultures; consequently the systematic position of the fungus is not known, nor is it possible to identify it. Professor Atkinson provisionally calls it *Ozonium*.

The first signs of the disease are usually noticed, about the time the plants are flowering, in the sudden wilting of a number of plants in the field. In reality the plants are attacked much earlier, but as, generally, only one or two plants in a field die, this is put down to some other cause. If the roots of plants which are attacked by the disease be examined, they will often be seen covered with the white, mould-like mycelium of the fungus. On the roots are also to be noticed depressions, the borders of which are at first red, but afterwards become brown. The main root very often forms an enlargement near the surface of the soil.

It has been noticed that the disease becomes more noticeable after rain which is followed by bright weather than during a long spell of dry weather. The main tap root is the first to be affected and usually the first point of attack is near the surface of the soil; in this, the *Ozonium* differs from many other root fungi, which attack first the young roots and the tips of the roots. The hyphae of the fungus penetrate into the tissues—the vessels and medullary rays—of the root: these hyphae may be seen to be continuous with the mycelium, which, as mentioned above, forms a covering to the root; these internal hyphae, however, do not turn brown as do the external ones.

The fungus absorbs its food supply from the root, it sets up fermentative changes at the spots attacked, resulting in partial decompositions of the root tissues, and so causes the depressed areas mentioned above. When the roots become seriously injured, the absorption of water and food salts from the soil is checked, more water is given off from the leaves than is taken in by the roots and the plant wilts. It is found that the lint of diseased plants is inferior to that of healthy ones. When one plant is attacked by the fungus it forms a centre for the spread of the disease; the infected area in this way increases from year to year, the fungus making its way through the soil from plant to plant.

As is often the case with soil-inhabiting fungi, no remedial measures have been found that will check the disease. The only method of keeping the disease under control seems to be by a rotation of crops. Many other crops, however, are attacked by the fungus, and these would be useless for a rotation. It

*Atkinson in 'The Cotton Plant' (p. 300), ibid.

is suggested that plants of the grass family, which includes sugar-cane, Indian corn and Guinea corn, would be suitable for this purpose. Cotton should not be planted on infected land for three or four years.

WILT OR FRENCHING.*

This is perhaps the most important of all the fungoid diseases of cotton, and it is also one of the most difficult to combat. Not only does it seem impossible to save a plant that has been attacked, but it is extremely difficult to eradicate the disease from a field in which it has once appeared.

The disease usually appears when the plants are from 6 to 8 inches high. The first sign of the disease is that the leaves, the lower ones first, turn yellow between the main veins or at the edges. The plants are dwarfed and unhealthy. Later, the leaves turn brown and fall off, and some plants die at once. The pale yellow colour of the leaf is very characteristic. On cutting across the stem, the woody tissues are seen to be coloured brown; this is the best naked-eye evidence of the presence of wilt disease. The roots very often offer good evidence as to the presence of this disease. The ends of the roots branch repeatedly, giving rise to little tufts of roots, instead of one long branch; this takes place especially when the plant is resisting strongly the attacks of the fungus.

The fungus appears able to infect uninjured plants, at least under some conditions. It was at first thought that it could only infect plants which had been previously injured by the eel-worm (*Heterodera*), already described, or by the damping off fungus to be described later. The fungus first enters the ends of the young roots, passes from these to the main roots and thence to the stem. The hyphae are to be found chiefly in the water-conducting elements (vessels) of the wood, and this explains why the first sign of the disease is the wilting of the foliage; the water and food salts from the soil are no longer able to pass up their natural channels and so the plant wilts. The presence of the hyphae in the vessels of the wood explains, also, the browning of the wood which is characteristic of the disease.

The fungus reproduces in four different ways. In living stems, small spores (*microconidia*) are cut off from the hyphae which, as mentioned above, are found in the water ducts of the stem. This is known as the *Cephalosporium* stage.

On the surface of dead stems we find large numbers of 'conidia beds,' which grow out from the mycelium inside the

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*Erwin F. Smith—'Wilt Disease of Cotton, Watermelon and Cow pea'. U.S. Department of Agriculture, Division of Vegetable Physiology and Pathology, Bulletin No. 17.

W. A. Orton—'The Wilt Disease of Cotton and its Control.' U.S. Department of Agriculture, Department of Vegetable Physiology and Pathology, Bulletin No. 27.

G. F. Atkinson—'Some Diseases of Cotton.' ibid.

G. F. Atkinson in 'The Cotton Plant' (p. 287). ibid.

Fletcher—'Notes on Two Diseases of Cotton'. *Journal of the Khedivial Agricultural Society and the School of Agriculture*, Vol IV, p. 238.

Delacroix—'Sur la Maladie du Cotonnier en Egypte'. *L'Agriculture Pratique des Pays Chauds*, Vol. II, p. 135.

tissues and on which are produced immense quantities of curved, septate spores (*macroconidia*). This is the *Fusarium*

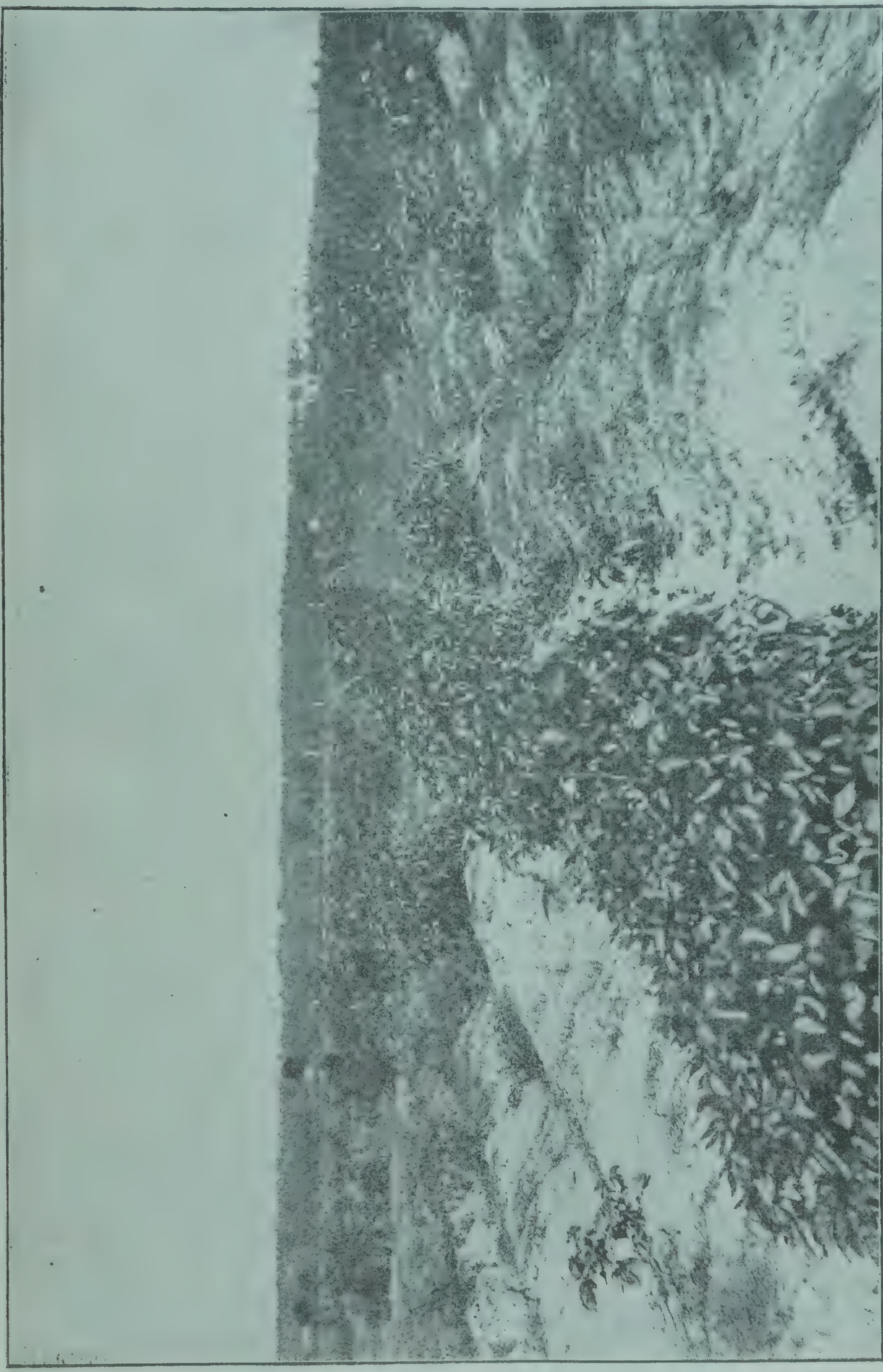

FIG. 2. A row of resistant Sea Island Cotton in a badly affected field. [From *The Wilt Disease of Cotton and its Control.*]

stage of the fungus, and can be produced in pure cultures from the mycelium which is found in diseased stems.

The third type of spore is the spherical *chlamydospore.* These spores are found on the surface of dead stems; according

to Dr. Delacroix they are more resistant and longer lived than the others.

The last and, systematically, the most important fructifications of this fungus are found on the roots, never inside the tissues of the host. They are little red *perithecia*, each of which contains numerous spore-cases or *asci*, in each of which there are eight *ascospores*. This fructification is of rare occurrence, and was not found by Mr. Fletcher in Egypt, nor by Dr. Delacroix in the material sent him from that country. This is the *Neocosmospora* stage of the fungus. A fungus, believed to be the same as this one, is found on ochro, also causing a wilt disease; this supposition does not rest on infection experiments, but on the fact, observed by Mr. Orton, that ochro, planted in a field infested with cotton wilt, always becomes infected with its wilt. Similar fungi cause wilt diseases of the melon and cow pea; the fungi causing these three diseases are so much alike that they cannot be distinguished one from the other under the microscope; numerous cross-infection experiments, tried by Mr. Erwin F. Smith, however, showed that each fungus was only able to infect its own host plant, the cotton wilt fungus being unable to attack either melon or cow pea, and *vice versâ*.

In Egypt, the disease does not seem to be so dangerous as in the United States: the fungus appears only to attack plants which have been previously injured by the 'damping off' fungus; this is definitely stated to be the case by Mr. Fletcher, and, as Dr. Delacroix describes a 'canker' at the base of the stem (which is a symptom of damping off but not of wilt), this would appear to be the case, also, with the specimens examined by him. This may be due to the superior powers of resistance possessed by Egyptian cotton over the ordinary Upland varieties, a fact which was proved by Mr. Orton; the resistance of Jannovitch to that of Sea Island and an ordinary Upland variety (King) being as 565 to 233 and 83.

As mentioned above, the usual methods of treatment are of little avail when used to combat the wilt disease. In some experiments carried out by Mr. Orton, the soil was treated with various fungicides, including Bordeaux mixture, copper carbonate, copper acetate, lime, sulphur, iron sulphate, carbolic acid, formol, caustic soda and kainit, but none gave any hope of success.

Rotation of crops is to be recommended, but it is not yet known how long the fungus will live in the soil; soils have been known to be still infested after a rest of four years. Ochro should not be planted on infected land.

The infected area should be isolated by means of a trench, which must be dug to a greater depth than that to which the cotton roots penetrate. The trench should also enclose two or three rows of healthy plants.

All diseased plants should be taken up and burned as soon as the disease is noticed; this will prevent the spread of the fungus by means of its spores.

Great care should be taken to keep diseased plants out of

the compost heap; if their presence be suspected, the manure must be used for land where cotton will never be planted.

The process that has been found of greatest service, in dealing with this disease, is the selection of resistant races. An experiment carried out by Mr. Elias L. Rivers of James Island, S.C., gives an idea of what can be done in this way. In 1899, he selected one healthy plant in a badly attacked field and saved the seed. This seed was planted in one row in a badly infested field, the other rows being planted with seed from plants grown in non-infected land. The result is shown in a photograph (fig. 2.) taken in September 1900, which is reproduced here. Of the ordinary cotton (Sea Island), 95 per cent. of the plants were killed, while not one plant was killed in the row that was planted with seed from the resistant plant. In 1901, an acre was planted with seed from this resistant row, and, although the land was infested, only two or three plants were attacked by wilt. In 1902, 15 acres were planted, again on infected land, and again the resistance was maintained. Seed of this cotton, now known as the 'Rivers' variety, is distributed by the Bureau of Plant Industry of the United States Department of Agriculture, as a special wilt-resisting race. Further details of this and of other resistant varieties together with directions for planting, continued selecting, etc., will be found on pp. 203-6 of this volume.

SORE SHIN OR DAMPING OFF.*

This disease usually attacks seedling cotton plants at or near the surface of the soil. Sometimes the tissues at this point simply rot and decay rapidly. At other times, one side only of the stem is attacked and an ulcer or canker is formed just below the surface of the soil; the diseased area in this case is marked by a reddish-brown colour. The depth of the ulcer varies, sometimes it only includes the superficial tissues, and then the plants very often recover, but sometimes the rot extends deeper and affects the water-carrying system, in which case the plants usually die.

The fungus which causes the 'damping off' of seedlings of a large number of plants is known as *Pythium de Baryanum*, and its development is favoured by the crowding together of seedlings, over-shading and too much moisture.

Professor Atkinson, although he was able to isolate the fungus that causes the damping off in cotton, grow it in pure cultures and infect healthy plants with it, was unable, either on the infected seedlings or in his pure cultures, to obtain any reproductive organs and so could not determine the systematic position of the fungus. Mr. Fletcher, however, was able in his artificial cultures to obtain the spores of the fungus causing damping off in Egypt and so was able to recognize it as a species of *Pythium*, though whether it is *Pythium de Baryanum* or an allied species could not be determined.

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*G. F. Atkinson—'Some Diseases of Cotton.' ibid.
Atkinson in 'The Cotton Plant' (p. 292). ibid.
Fletcher—'Notes on two Diseases of Cotton.' ibid.

The chief danger of this disease lies in the fact that the ulcer, formed at the base of the stem, is an easy point of entrance for the spores of the fungus causing wilt. In fact, it would appear that, in Egypt, only plants which have previously damped off and recovered are attacked by wilt.

YELLOW LEAF BLIGHT OR MOSAIC DISEASE.*

This disease of the leaves is not due, primarily, to the attack of fungus or insect parasites, but to an unsuitable condition of the soil as regards the proper supply of food salts or proper mechanical condition.

The first sign of the disease is a peculiar yellowing of the leaf, giving the latter a mosaic appearance. The yellow colour appears in small, rectangular areas, which are bounded by the small veins. Near the veins the green colour persists, as these parts of the leaf, being nearer the channels by which water and food materials are carried, are better nourished than the rest.

Later on, the yellow colour is masked by others, produced by the growth of numerous fungi which are able to get a footing on the weakened tissues of the leaf. Two fungi that are commonly found in such cases are *Macrosporium nigricantium* and a species of *Altenaria.* Both these fungi possess black hyphae and spores, and so give a black colour to the leaf, hence the later stages of this disease are often known as 'black rust.'

The proper treatment for the disease lies in the correct application of manures and proper cultivation of the soil. In some experiments carried out by Professor Atkinson, kainit was found to have an influence on the disease. This effect is attributed to the mechanical action of this manure in rendering the soil more retentive of moisture or better able to draw it up from below. The method of cultivation, adopted by the most progressive planters, is to cultivate the soil thoroughly before planting the cotton and afterwards only to cultivate the surface soil to a depth of a few inches; the layer thus cultivated acts as a mulch in preventing the loss of water from the soil.

RED LEAF BLIGHT.§

Cotton leaves, when the plant is approaching maturity, frequently turn red, even when the plant is quite healthy. This is a normal phenomenon and allied to the colouration produced in 'autumn leaves' in temperate regions.

On poor soils, however, the red colour may appear when the plants are quite young. In this case, the plants mature prematurely, the leaves drop and only a few bolls are produced. This appearance indicates a lack of nourishment in the soil, especially a deficiency in the amount of nitrogen and potash present.

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*Atkinson in 'The Cotton Plant' (p. 279). ibid.
§Atkinson in 'The Cotton Plant' (p. 284). ibid.

ANGULAR SPOT.*

This is not an important disease; it seldom appears to a sufficient extent as to be very noticeable. Small spots on the leaves, bounded by the smaller veins, show a watery appearance; the spots frequently follow the main veins of the leaf; they often join together and in their later stages become black and then light brown. The disease hastens the falling of the leaves.

Large numbers of bacteria are present in the spots in the early stages of the disease, as the watery appearance is just beginning. Professor Atkinson suggests that these bacteria may be the cause of the disease, but no infection experiments were successful. It may be that the bacteria are only able to infect older leaves (in which the disease usually appears) or leaves which have been weakened from other causes.

LEAF BLIGHT.†

This disease, which is of fairly common occurrence in the United States, is due to a fungus, *Sphaerella gossypina*. Though common, the fungus as a rule attacks only old leaves, or leaves which have been weakened by imperfect nutrition and so the disease rarely becomes of any importance.

The spots formed on the leaf are irregular and roundish, they are brownish-white in the centre with a dull, reddish margin. In the young stages, the spots appear as small reddish dots. The fungus is found in the centre of the spots; the mycelium is found inside the tissues and from it are given off numerous conidiophores which penetrate through the skin of the leaf and bear numerous spores. These spores when carried to another leaf again give rise to the disease. This fungus is one of those that appear on the leaf in the later stages of the mosaic disease.

AREOLATE MILDEW.‡

This disease is of interest on account of its occurrence in the West Indies. It is, however, of no very great importance, as it seems to damage only the older leaves and to do very little harm. The fungus causing it is known as *Ramularia areola*.

The disease is characterised by appearing on definite small areas of the leaf, which are bounded by the veins. The diseased areas, when looked at from above, have a yellow tint; they are more transparent than the rest of the leaf and have a frosted or mildewed appearance.

The mildewed appearance is due to the numerous short spore-bearing filaments (*conidiophores*) of the fungus. The vegetative part, or mycelium, of the fungus grows inside the tissues of the leaf, and from this are put out small clusters of conidiophores on which are borne the reproductive bodies, the spores; these occur in considerable numbers. The spores are

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*Atkinson in 'The Cotton Plant' (p. 286). ibid.
†Atkinson—'Some Diseases of Cotton,' ibid.
‡Atkinson—'The Cotton Plant' (p. 308). ibid.

carried by wind or other agencies to other leaves, where they germinate and cause disease again.

As has been mentioned already, the disease is not a dangerous one, nor does it cause serious loss to the crop. It might be as well, however, especially if the disease is at all common, to spray the young leaves once or twice during the season with Bordeaux mixture, as a preventive measure.

COTTON RUST.*

This is another leaf disease which has already been noticed as attacking cotton in the West Indies. The fungus causing the disease is known as *Uredo gossypii*, it belongs to the group of the true rusts, many of which cause very serious diseases of cultivated crops, especially wheat and other cereals, in temperate regions.

The disease was first noticed by Professor Lagerheim on South American cotton in 1893 ; he states that it was causing considerable damage, largely reducing the yield of lint.

The disease attacks all green parts of the plant. It produces, on the upper side of the leaf, small, purplish-brown, roundish or angular spots ; the spots may be scattered or some may be joined together.

The spores are produced in clusters mainly on the under side of the leaf. They are formed first under the epidermis, and afterwards break through, each spore cluster forming a small pustule.

Exactly how much damage this fungus is likely to cause in the West Indies cannot yet be stated, but it would appear that it does not severely attack healthy plants, but only such as are weakened by age, unfavourable conditions, insect attacks, etc.

Once the disease is well established in a field no remedial measures are likely to prove successful. Should the disease become frequent and severe, it will be necessary to spray the young leaves, before they show any signs of being attacked, and spray again three or four times during the season.

SHEDDING OF BOLLS.†

This is another disease which is not due to any insect or fungus parasite, but to external conditions which are unfavourable to the growth of the plant.

The fruit and the fruit-stalk become first of a paler green colour than the healthy parts of the plant. Later on, the separation of the unhealthy parts takes place, and the fruit either drops off completely, or hangs by only a few threads ; the cleanness of the cut varies considerably.

The usual cause of the disease is an extremely wet or extremely dry season, or the change from very wet to very dry

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*Lagerheim. 'A new Cotton Rust in Ecuador.' *Journal of Mycology*, Vol. VII, p. 47.

†Atkinson—'Some Diseases of Cotton' ibid.
Atkinson in 'The Cotton Plant' (p. 285), ibid.

weather, and *vice versâ*. Any of these causes bring about a lessening of the nutrition of the plant, which is then unable to bring all the bolls to maturity. Sometimes during the early part of the season conditions are very favourable and a large number of young bolls are formed; later, the season becomes more normal, the plant cannot mature all of them and so a number are shed.

COTTON BOLL ROT.*

This disease is due to the action of a bacterium (*Bacillus gossypinus*). The rot begins within the boll, as a small, dark brown area, which includes the young seeds, starting at a point near the point of attachment of the fruit to the fruit-stalk. The rot spreads throughout the contents of the boll until they are all decayed, and it is not till this happens that the disease is apparent from the outside, as the walls of the fruit then begin to appear diseased. If the disease starts when the boll is still young, the whole contents will decay and the boll will not open; the rot may, however, begin comparatively late and then only a small part of the lint is affected and the boll opens.

The manner in which the bolls are infected is not yet determined. It was at first suggested that infection took place at the roots, and the bacteria spread from these up the stem to the flowers and fruit. Another suggestion was that infection took place by means of insects when the plants were flowering, the young ovary being directly infected. There is also the possibility that the bacteria may remain attached to the seeds and the young plant be infected as soon as these germinate. In some cases the fruits would appear to be infected with the bacteria by certain insects which puncture the bolls.

Spraying, of course, is of no avail in dealing with this disease, as the bacteria are inside the tissues and would not be reached by the chemicals. Diseased bolls should be gathered and burned as soon as the disease is discovered, or, at least, when the lint is being picked. The field should be gone over again, for this purpose, as soon as all the lint has been picked. Seed coming from a gin in which diseased cotton has been ginned, should not be planted.

ANTHRACNOSE.†

This disease, which causes damage mainly when it attacks the bolls of cotton, is due to a fungus (*Colletotrichum gossypii*). It is one of the few fungoid diseases of cotton that occurs in the West Indies. At times, the disease has been known to cause a loss of 10 to 50 per cent. of the crop, but, up to the present, it has not done any great damage in these islands.

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*Atkinson in 'The Cotton Plant' (p. 310). ibid.

†Atkinson in 'The Cotton Plant' (p. 293). ibid.

Atkinson—'Some Diseases of Cotton.' ibid.

E. A. Southwell—'Anthracnose of Cotton'; *Journal of Mycology*, Vol. VI, p. 100.

Atkinson—'Anthracnose of Cotton'; *Journal of Mycology*, Vol. VI, p. 173.

The first sign of the disease on the bolls is the appearance of minute reddish-brown spots. The spots enlarge and the tissue blackens, the margin of the spot remaining reddish-brown. The next stage is due to the development of the spores of the fungus; these appear in small pustules, which are crowded together in the centre of the spot. If only a few spores be developed, the colour of the centre becomes a dirty grey; but if these are numerous it becomes a bright pink. The spots now show a reddish-brown margin, inside this a band of blackened tissue, and following this the grey or pink centre. Very often the spots join up and form large, irregular diseased patches. Various stages of the disease on the bolls are shown in fig. 3.

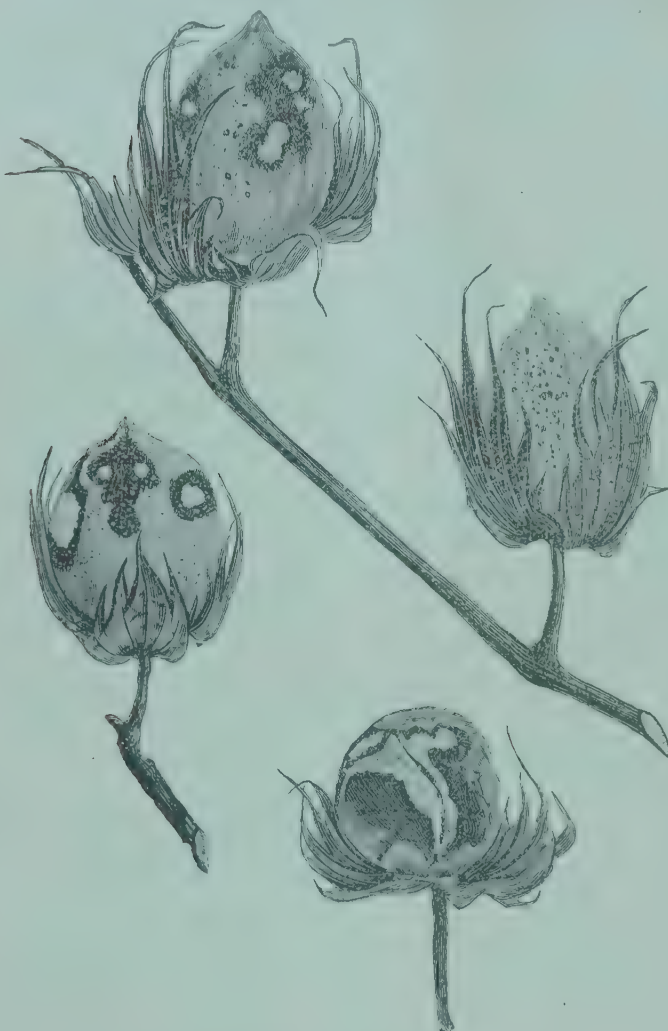

FIG. 3. Cotton Bolls showing Anthracnose. [From *The Cotton Plant.*]

Fruits attacked by the fungus do not mature well; the tissues ripen prematurely and become dry and dead without opening properly. Sometimes the fruits do not open at all but, usually, they open slightly at the top, the lint being firmly held within. Frequently the fungus may be found on the lint.

At times the whole of the fruit is attacked at a very early period, so that the boll is dead before a large development of spores has taken place. The boll then appears nearly black, owing to the numerous black hyphae, etc. of the fungus.

The fungus sometimes attacks the stems, particularly of seedlings; in the latter case, it usually attacks them near the surface of the soil and makes the plant wither and die as if it were damping off. There is not, however, as is the case with the true damping off disease, any well-defined ulcer.

Leaves, also, are sometimes attacked by the fungus. It does not, however, seem to attack healthy leaves, but only such as have been weakened by injury or poor nutrition. The chief danger of the fungus on the leaves is that spores are formed there, which may infect the bolls. The seed-leaves (cotyledons) are sometimes badly attacked, especially when they

have been injured in being withdrawn from the seed-coat, a sometimes happens, particularly in dry weather.

As already mentioned, the fungus spreads by means of spores which are formed on all diseased parts ; the spores are carried from one plant to another by wind and insects. Spraying the young bolls with some fungicide, such as Bordeaux mixture, would probably prevent the germination of spores carried there in this way and so prevent the infection of the bolls.

It is possible that the disease in seedlings and cotyledons is caused by spores, held in the lint, which in Upland cotton remains attached to the seeds, or by seeds which are attached to the seed-coat. In this case the proper treatment would be to sterilize the seeds, by soaking them either in hot water or in a dilute solution of copper sulphate (blue stone).

In any case the greatest care should be taken to destroy all diseased plants and parts of plants. The fungus is capable of living saprophytically on these if they are simply left on the ground, and will spread from them to healthy plants. The diseased parts may be burned, or they may be buried, preferably mixed with lime, in soil which will not be planted in cotton for some time.

INSECTS ATTACKING COTTON IN THE WEST INDIES.

BY HENRY A. BALLOU, B.Sc.,

Entomologist on the staff of the Imperial Department of Agriculture for the West Indies.

Although it is known that cotton was cultivated in the West Indian Islands many years ago, there seems to be no record of the insects which attacked it. Many of those who can remember the days of cotton cultivation here, know that worms used to eat the leaves of the plants, causing great damage, but very little seems to be known of the methods employed against them.

The United States Department of Agriculture has done a great deal of work in connexion with cotton cultivation, and its publications, together with those of the Experiment Stations in the various States in which cotton is grown, form a very large proportion of the literature to be found on the subject. From this fact, and the fact that the present crop of cotton is only the second since the revival of cotton cultivation in these islands under the direction of the Imperial Department of Agriculture, it will be seen that it has been necessary to draw on these publications, to a large extent, in preparing a preliminary account of the insects attacking cotton.

The Cotton Boll worm (*Heliothis armiger* Hübn.) and the Mexican Cotton Boll weevil (*Anthonomus grandis* Boh.), which are so common and destructive in the cotton districts in the United States, are not known in the West Indies, and for descriptions of these, especially, free use has been made of the publications mentioned above.

The illustrations used have been obtained from the United States Department of Agriculture and originally appeared in its publications.

We are indebted to Dr. L. O. Howard, Chief of the Division of Entomology, United States Department of Agriculture, for the identification of *Dysdercus annulliger* Uhler, *Dysdercus andreae* Linn., and the Cotton Leaf blister-mite.

The only distinctive pest of cotton, so far found in the West Indies, is the Leaf blister-mite (*Phytoptus* sp.) found in Montserrat and later in St. Lucia and St. Kitt's.

Other pests are the same as, or closely related to, the pests of the American cotton-growing districts.

THE COTTON WORM.

(*Aletia argillacea* Hübn.)

This is one of the most common of all the insects attacking cotton and is well known in most of these West Indian Islands, and will probably be found in all, as the areas planted in

cotton increase. It is thought to be native to the West Indies or at least to tropical America. This insect has a wide geographical range, being found as far north as Canada, at certain times; but so far there is no evidence that it breeds and goes through its life-changes further north than the cotton-growing States.

The egg: The egg is laid upon the under side of the younger leaves near the top of the plant. Each female moth lays a large number of eggs which are generally scattered and rarely, if ever, in clusters. The egg is pale green in colour and quite easily distinguished upon the surface of the leaf. Seen from above, the egg presents a circular outline, but viewed from the side it appears rather elliptical or as if flattened from above. If it be examined with a pocket lens, its surface will be seen to be marked with fine lines or ridges radiating from the centre above. The duration of the egg stage in midsummer in the United States is given as three to four days, and in cooler weather slightly longer.

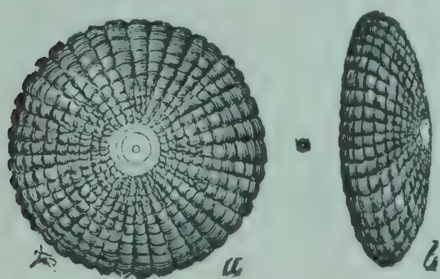

FIG. 1. Egg of *Aletia argillacea*, greatly enlarged. *a*, dorsal; *b*, side view.

The larva: When the young caterpillar first leaves the shell, it is very small and not easily seen, so nearly is it of the colour of the under surface of the leaf, where it remains a short time and begins feeding. At first it does not eat the tissue of the leaf clean but merely gnaws away the under surface which is much more tender than the thicker upper surface. As it grows older it eats the entire tissue of the leaf except only the largest veins. This insect is one of the 'loopers' or 'measuring worms.' These names are given because the larva travels by arching its body and bringing up its hind legs to the forward ones and then reaching out again to get a new hold with the forward pairs. This peculiarity is shown even in the earliest stages.

These caterpillars snap from side to side very quickly when disturbed and frequently with such force as to throw themselves off the leaf, and the younger ones spin a fine silken thread from which they may be seen dangling in the air 5 or 6 inches below the leaf from which they have fallen.

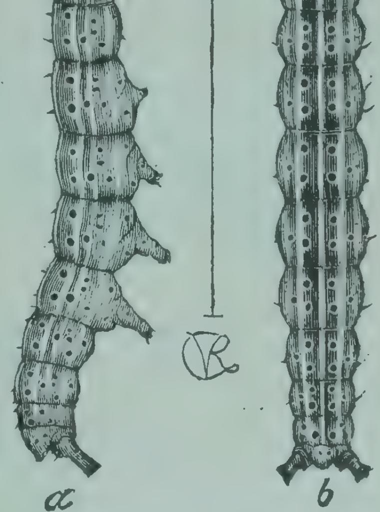

FIG. 2. Cotton worm. Larva of *Aletia argillacea*, enlarged; actual length indicated by hair line. *a*, side; *b*, dorsal view.

The development of the caterpillar requires from one to three weeks and during this period the skin is shed five times. When first hatched, the larva is yellowish in colour but soon becomes greenish, with numerous black spots and yellowish longitudinal lines. The fully grown larva measures nearly $1\frac{1}{2}$

inches and is quite slender. The head is dull olive-green; a very fine bluish-white line extends along the middle of the back the entire length of the body. On either side of this fine line is a wider green line; each of these being, in turn, bordered by a yellow band. There are two rows of black spots along the back—one row in each of the yellow bands—each of the black spots has a fine stiff hair or bristle arising from its centre, and careful examination will show a fine white ring outside the black of each spot.

The sides are olive-green with several more or less interrupted lighter lines running lengthwise, the lower one being continuous. There are black spots on the sides also, which are like those on the back except that they are smaller, and are not arranged in regular rows. There is much variation in the colour of the larvæ at different seasons of the year, the earlier broods being lighter and the later ones darker.

The pupa: When the caterpillar is fully grown, it spins a thin scant cocoon, inside which it pupates. The cocoon usually consists of a few whitish, silken threads which hold the pupa on the under side of the leaf, the edge of the leaf being frequently slightly rolled or drawn under. The pupa is at first greenish, but soon becomes dark-brown. It is a little more than $\frac{1}{2}$ inch in length. One week to thirty days is the length of time given for the pupa stage in the United States.[1] Probably in the West Indies the time of pupation will not extend over more than two weeks on account of the uniformly warm weather.

The adult insect: The adult or winged insect of the cotton caterpillar is a small greyish moth with a spread of wings from $1\frac{1}{8}$ to $1\frac{1}{2}$ inches. There are several fine, wavy, dark lines running across the forewings, and one or two small bluish-white spots in each forewing toward the front.

The moth is a night-flyer, hiding by day, and when disturbed, flying with short, swift darts. At night it flies out to feed and lay its eggs. Egg-laying begins a few days after the female leaves the chrysalis and each female lays a large number of eggs—300 to 500. Many moths are unable to feed, others merely suck the juices of flowers and fruit; but this one has a peculiar proboscis by which it is able to pierce the skin and tissues of ripe fruits, etc., upon which it feeds. It also feeds upon the nectar of flowers, etc.

FIG. 3. Adult of *Aletia argillacea*. *a*, wings spread; *b*, wings folded, natural resting position.

Further experimental work is still necessary to show how many broods there are in the West Indies, and at what times they appear; but it is probable that breeding continues all the year round, and that the larger numbers at certain times or seasons are due to the increased amount of cotton available at

those times. Five broods are known to occur each year in the United States.

The eyes are dark, velvety-brown, large and prominent. Palpi are large and are directed forward and upward in front of the eyes. Between the eyes the long, slender proboscis is coiled up like a watch spring.

The antennae are a light, yellowish-grey, long and slender and composed of a large number of small segments. When at rest, the wings are closed upon the body, the forewings nearly meeting over the abdomen, and sloping down over the sides, roof-like. The under surface of wings and body as well as the legs are light grey, much lighter than the upper surfaces.

Natural Enemies and Parasites: Up to the present time very little is definitely known as to the natural enemies of this insect in the West Indies. It is probable, however, that as the acreage of cotton increases, and the cotton worms become more numerous, many parasites and predaceous forms will appear. Already several observations have been made as to the cow bee and wild bee (*Polistes* sp.) feeding on the caterpillars; and birds and parasitic insects will most likely soon become accustomed to the new source of food and will greatly help in keeping down the numbers of this insect.

Remedies: Extensive experiments have been carried on in the United States to ascertain the best methods to be employed for controlling this insect; and the most simple seems to be the most practical and at the same time sufficiently effective. This consists of a pole with a bag of coarse sacking at each end. The pole is just long enough for the bags to hang over two rows of cotton, and the apparatus is used by a boy mounted on a mule, carrying it in front of him. Paris green is put into the bags and is distributed by jarring the pole with a short stick. By this method one man or boy on a mule can poison from 15 to 20 acres in a day. This method has not been tried in these islands, but good results have been obtained from the use of Paris green and lime applied dry, at the rate of 1℔. Paris green to 100 ℔. lime. The lime should be very dry and finely sifted and is applied from a bag of coarse cloth. Further experiments are necessary to indicate about how much of this material will be used for each application and how large an area a man can cover in a day. Preliminary trials indicate about 3 acres as a day's work.

The method of planting cotton in double rows as practised in certain of these islands, and the strong breezes which are almost continually blowing, together with the general absence of mules or horses trained to field work, would all seem contribute to make the hand method and use of lime and Pari green more practical than the United States method. Spraying is also practised with good results.

THE COTTON BOLL WORM.

(*Heliothis armiger* Hübn.)

The first indication of the presence of this insect would probably be the falling of large numbers of bolls. The boll

would show on examination a small round hole on one side and if it were examined soon after it dropped, would be found to contain a small caterpillar, though cotton bolls are shed from other causes, such as the Mexican cotton boll weevil, fungi and excessive moisture.

At one time this pest was one of the most serious in the United States, but since the adoption of rational control measures it has become of minor importance. These control measures consist for the most part of planting corn as a trap. The boll worm prefers corn, especially the young ear, to cotton, and if a sufficient amount of corn be present, the first generation of caterpillars may be trapped in the corn, which can then be fed to stock or destroyed, thus killing the caterpillars in the ears. Owing to its attacking other fruits, it has received the name of tomato worm and corn ear worm, and besides these it has a remarkable variety of food plants. At the present time no insect has been reported attacking the cotton bolls in the West Indian Islands.

THE MEXICAN COTTON BOLL-WEEVIL.

(*Anthonomus grandis* Boh.)

This insect was first known in the United States in 1894, and each year since it has steadily spread north and east, with the exception of 1896; and it is estimated that only about fifteen years will be required for it to infest all parts of the cotton-growing area of that country. In 1896, there was a severe drought in the infested area, which is supposed to account for the failure of the weevil to gain ground in that year. It had long been known as a cotton pest in Mexico, but not until it invaded Texas in 1894 was any systematic study of its habits and life-history attempted, nor was it known how serious a pest it might become. It is now recognized as one of the most serious of the insects with which cotton planters have to contend, and the United States Department of Agriculture has for several years had experts stationed in the infested districts for the purpose of studying the habits of the weevil and experimenting in means for its control.

The adult of the boll-weevil is a small greyish weevil, about $\frac{1}{4}$ inch in length. The larva is about $\frac{3}{8}$ inch in length when fully grown and lives entirely within the unopened buds (squares) or the bolls, feeding on their interior substance. The affected squares usually drop, but the bolls generally remain upon the plant, becoming stunted or dwarfed, except late in the season, when they either dry or rot.

Practical measures for the control of this pest have been suggested by the United States Department of Agriculture.[2]

These consist of (1) trap rows of cotton from which the weevils can be collected; (2) spraying with poisoned sweets; (3) cleaning up all fallen squares and destroying them; (4) grazing off the late squares by turning in cattle; (5) trapping into hibernating quarters, such as rubbish of all kinds, cotton stalks, corn, etc., and then burning. Although Cuba is now believed to be the original home of this insect, it is not known to occur in the British West Indies.

THE WHITE MARKED COTTON STAINER.

(*Dysdercus andreae* Linn.)

Colour—red, with black and yellowish-white markings.

Length—½ inch (12 mm.)

Head: small, red, triangular.

Proboscis—composed of four segments, red, darker towards tip, inserted at extreme anterior end of head, and reaching back nearly to third abdominal segment.

Eyes—large, black, prominent, situated well back and reaching the flattened upper surface of the head.

Ocelli—none.

Antennae—black, composed of four segments, inserted upon a projection of the cheek, which simulates an antennal segment. Basal segment equal in length to the apical, second longer than third, second and third together longer than the first. Segments 2 and 3 smaller at base, enlarging gradually towards apex, tipped with a reddish colour. Apical segment uniformly black, spindle-shaped.

Thorax: red, segments bordered with yellowish-white. The prothorax bordered both anteriorly and posteriorly by a yellowish-white line, the anterior line extends entirely around, the posterior terminates in a large white spot on each side at the base of the fore leg. These whitish lines are bordered by black, which is quite conspicuous above, less so on the sides. Dorsal area finely punctured, a transverse groove and ridge extending between the humeral angles. A sharp lateral carina extends from just behind the eye to the humeral angle of the pronotum; this carina is marked with black.

Pronotum has a slight longitudinal depression. Sides slightly rugose.

Meso- and metathorax, bordered with whitish lines which terminate in white spots at bases of second and third pairs of legs respectively.

Legs: slender, black, except basal portions of femora, which are dark-red.

The femora of the first and second pair of legs are provided with one or two pairs of short, stout, sharp spines on the under side near the apex, which are directed slightly forward. One pair of these spines is always present, the second sometimes very small or wanting.

Posterior femora without spines.

Tibiae with few fine spines.

Tarsi with many short hairs.

Scutellum dark-red, anterior margin black.

Wings: When the wings are folded the upper surface of

the wing area presents a very handsome and characteristic pattern.

The anterior portion shows a black triangle, with its base to the front, in the centre of which is the dark-red scutellum; the posterior portion is also black. The anterior portion is angular, the posterior rounded. These black areas are all bordered with white, the white lines crossing in the middle of the back forming a letter X. The side areas are bright-red. Just below the crossing of the white lines are two sub-triangular black blotches, which extend nearly across the red areas.

Clavus—red, a white line running between clavus and embolium and between clavus and corium. This is bordered with a narrow black area on the embolium side, which terminates just below the anal angle in a large sub-triangular blotch which extends nearly across the clavus.

Embolium—black. Corium—black, outer margin narrowly whitish.

Underwings, membranous, irridescent, hyaline, smokey towards outer margin. Veins honey-yellow.

Abdomen: Reddish, flattened above; sub-angular below. Segments bordered with white. Lateral areas more or less smirched with black.

Egg: Not known.

Young: At first red, legs and antennae blackish. Wings first appear as small black pads on the thorax. The white markings are indicated by fine white lines at a very early age.

Found in Antigua, St. Kitt's-Nevis and Montserrat.

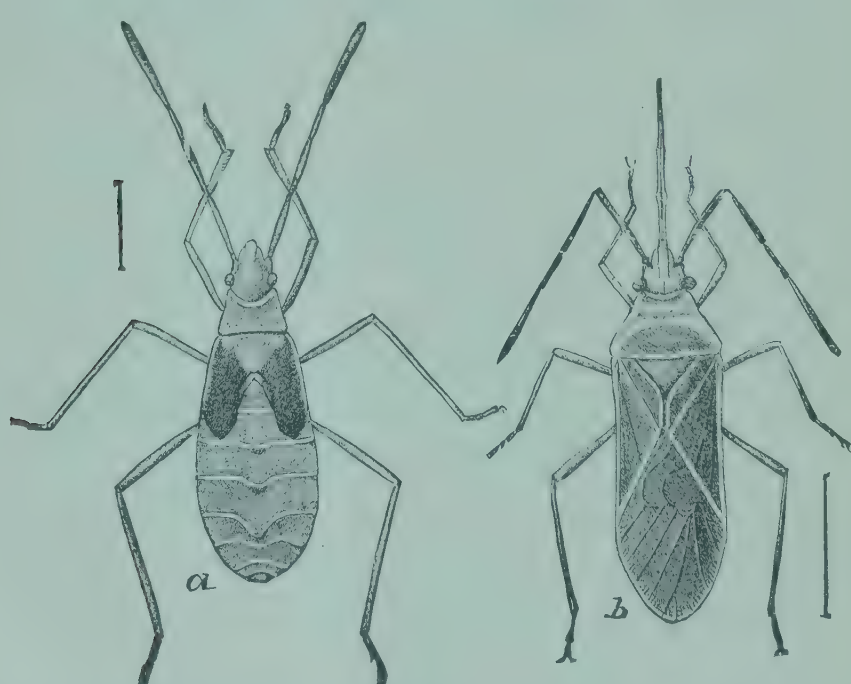

FIG. 4. *Dysdercus suturellus.* Cotton Stainer of the United States, closely related to the White Marked Cotton Stainer of the Northern Islands.
a, young; *b*, adult; actual length represented by hair line.

Specimens of the White Marked Cotton Stainer were submitted to Dr. L. O. Howard, Entomologist to the United States Department of Agriculture, who has replied that Mr. Heidemann of that Department identifies them as *Dysdercus andreae* Linn. This species has a wide geographical range, occurring in Jamaica as the Cotton Stainer of that island.

COTTON STAINER OF SOUTHERN ISLANDS.

(*Dysdercus annulliger* Uhler.)

This insect is much like the preceding, to which it is evidently closely related.

It differs principally in the following :—

Body : stouter and entirely without the white markings which characterize *Dysdercus andreae.* The apical segment of the antenna has at its base a white band, which varies in different specimens, but is generally about a quarter of the whole segment. In some cases the bases of the antennal segments are reddish, and even the whole of the basal segment may be reddish. Median depression of the pronotum very slight.

Legs : nearly all red, tarsi blackish.

Tibial spurs on anterior legs only.

Scutellum : black or slightly reddish.

Wings : blackish, sometimes reddish anteriorly, blackish posteriorly. The black of the wings is not a clean, deep black as in the former.

Found in Barbados, St. Lucia and St. Vincent.

Damage by Cotton Stainers : Opinion is much divided as to the actual damage which these insects do to the cotton, some planters maintaining that the stainer injures the cotton only by staining the cotton either by its excrement in the opening boll in the field, or by being caught in the gin and crushed, thereby imparting a strong stain to the fibre. These stains are a serious injury to the cotton when it is offered for sale. Other planters believe that the stainers in puncturing the bolls and sucking the juices, cause the outer surface to become so hard and dry that they can not open properly, and as a result the cotton is matted and of inferior quality. These bugs also enter the opening bolls and suck the juices of the ripening seeds, and it is at this time that much of the staining is done.

No careful observations on the feeding habits of the cotton stainers in the West Indies are to be found on record.

Little seems to be known of the natural enemies of these insects, and even in those fields which have been badly infested, no parasitic or predaceous insects have been observed, which would be likely to serve as a check on them to any considerable extent.

Remedies : Cotton seed and pieces of cane put in small heaps at intervals in the fields will serve as traps for them. When the bugs collect at these places to feed they can be killed by hot water or by spraying with kerosene emulsion or other contact poison.

In badly infested fields, the cotton may be cut after the crop is off and piled in windrows and when the bugs have re-assembled on it, the whole can be burned. Large numbers of the bugs can be destroyed in this way.

In addition to the cotton stainers, several other bugs are reported as doing more or less damage to growing cotton in these islands. Like the cotton stainers these insects feed by sucking the juices of the plants they attack.

The Green Bug (*Nezara viridula* L.) is of bright, leaf-green colour, slightly darker on antennae, legs towards extremities, anterior portion of scutellum, and apical portions of wings; length $\frac{2}{3}$ inch (15 mm.), width across at posterior part of pronotum $\frac{1}{3}$ inch (8 mm.).

The Brown Bug (*Edessa meditabunda* Fabr.) is a trifle smaller than the preceding, measuring about $\frac{1}{2}$ inch in length, and $\frac{1}{4}$ inch in width. Colour, greyish-brown, darker on antennae, legs and wings: scutellum, more or less tinged with greenish.

These two bugs are quite common on cotton, and a variety of other plants, but there have not been sufficient observations made as to the actual damage they do.

The Shield-backed Bug (? *Eurygaster* sp.) is a peculiar bug found only in St. Lucia, and is also reported as injuring cotton. This insect has the scutellum so elongated that it reaches to the tip of the abdomen. Like the preceding, it is not well enough known to allow any statement as to its destructiveness. It is generally considered however that the shield-backed bugs are not serious enemies to vegetation.

COTTON PLANT LOUSE.

(*Aphis gossypii* Glover.)

This insect is known to attack a large variety of plants, and has in the past borne several different names according to its food plants. It also is very variable in its colour, and it was supposed that several species of plant lice attacked the cotton. At present, however, it is known that cotton is rarely, if ever, infested with any other species than the one under discussion. It is most injurious when it becomes very abundant on young cotton, and by curling up and destroying the tender leaves, frequently causes serious damage. Later in the season the injury becomes less and less as the plants become more vigorous and better able to withstand the injurious effect of the sucking of this pest. In addition to this, the natural enemies of the pest increase rapidly and greatly assist in keeping it in check.

It was reported in Montserrat in 1894, by Mr. H. G. Hubbard, as attacking young leaves; it has been quite abundant in Barbados on this crop, and has occurred in St. Vincent and Montserrat. Probably it is to be found in all the other West Indian Islands where cotton is being grown, but no exact records are at hand.

This plant louse can be easily distinguished from any other insect pest on cotton. It is very small, pale green or yellowish

in colour. The body is rather pear-shaped. The eyes are dark, prominent and conspicuous. Legs are well developed, and both young and old walk quickly. The distinguishing feature of the aphis is to be found in the honey tubes, which are small projections situated upon the dorsal surface of the abdomen. They are rather wide apart and point to the rear. These honey tubes excrete a sweet substance, called honey dew, upon which ants are fond of feeding, and for the sake of which they frequently care for the aphis and carry it to new feeding places. Many infestations of plants by plant lice are due to this action on the part of the ants.

Remedies: The cotton aphis being a soft-bodied, sucking insect, would be readily killed by the use of any ordinary contact poison, such as whale oil soap or kerosene emulsion, but in most cases it will probably pay better, for the reason already stated, to replant than to apply these remedies. Egyptian, Peruvian and Sea Island cotton have all been attacked by this pest this year in Barbados, and in every instance that has come to the writer's notice the plants have out-grown the attack.

Natural Remedies: Two lady-bird beetles (*Cycloneda sanguinea* and *Megilla maculata*) and the Aphis Lion (*Crysopa* sp.) are very plentiful on and about the plants attacked by the cotton aphis.

It is largely due to the efforts of these that the cotton outgrows an attack of aphis. These exceedingly useful insects increase rapidly in numbers, and feed so voraciously upon the aphis that the cotton has a very good opportunity to grow away from the pest.

The following technical description of this insect is from *Insect Life* and forms part of an article on 'The Cotton or Melon Plant Louse' by Theodor Pergande:—

Apterous viviparous female: Length of the fully mature female 1·6 – 1·8 mm.; greatest diameter across the abdomen, about 0·6 mm. Abdomen pyriform; antennae rather short and slender, reaching to, or beyond, the middle of the abdomen. Nectaries, about twice the length of hind tarsi, conico-cylindrical. Rostrum rather stout, reaching nearly to third coxae. A prominent conical and fleshy lateral tubercle may be observed each side of the prothorax and behind the nectaries, and four smaller ones each side of the abdomen in front of the nectaries.

Colour very variable, even in the same colony. The oldest females may be either yellow or different shades of green to black, frequently marked with irregular darker shadings: this variation in colour is, however, often as pronounced in the different younger stages. Eyes, dark-brown. Antennae, whitish or pale yellowish with the apex of the sixth and the last joint black; legs, white or pale yellowish; the coxae, apex of tibiae, and the tarsi, dusky or black. Nectaries, black: tail, greenish or dusky. All are covered with a very delicate, more or less observable, pruinose excretion.

Pupa: Colour also quite variable, varying in different individuals from dark-green to orange or reddish-brown, though in some cases they are of a beautiful, pale, bluish-grey. Head

and prothorax dusky ; the meso- and metathorax either whitish, yellowish or glaucous-green, frequently marked with two faintly dusky medio-dorsal stripes. Wingpads and nectaries black ; the rest as in the apterous female. The whole body is more or less distinctly pruinose and generally marked on the abdomen with four longitudinal rows of round, white, pulverulent spots, which give them a peculiarly pretty appearance.

Winged female: Expanse of wings, 4·6 to 6 mm. ; length, 1·2 to 1·8 mm. Shape more slender than in the apterous form, antennae barely reaching to nectaries. Legs longer and more slender, and the nectaries and tail rather shorter, than in the apterous form. General colour yellow, yellowish-green or quite dark-green, with the base of the abdomen in the darker forms more or less distinctly orange. Eyes dark-brown, antennae black, head, a broad band across the prothorax, mesothoracic lobes and sternal plate, four lateral abdominal spots and nectaries black. Remaining parts of thorax more or less decidedly orange. Legs, yellowish ; the coxae, apical portion of femora and tibiae, and the tarsi, blackish. Rostrum yellowish, its base and apex blackish. Tail greenish or dusky ; wings delicate, colourless, irridescent, base and subcosta more or less distinctly yellowish. Veins black and very slender. Stigma pale greenish or yellowish-grey. Antennal joints, except the two basal ones, distinctly serrated or imbricated. Joint seven is somewhat the longest, while the third comes next in length ; joints four and five are subequal in length, each somewhat shorter than the third ; joint three provided with a quite regular, straight row of five to seven sensoria and one near apex of fith and sixth joints.

The sexes have so far remained unknown, though the winter eggs, which resemble closely those of other aphides, were discovered on *Portulaca* and strawberry ; they measure about 0·6 mm. in length and are of a regularly oval shape. Their colour is yellowish or greenish when recently deposited, but soon changes to jet black.

SCALE INSECTS.

There are two common scale insects found on cotton in these islands, but they are scarcely to be considered as serious pests. Scale insects rarely become numerous enough on plant cotton to make remedial measures necessary, although in one instance at least, a crop of young cotton has been so seriously attacked as to make it necessary to destroy the whole field. This field was bordered by an hibiscus hedge which was seriously affected by *Lecanium nigrum*, and the scale spread from it to the cotton. On the other hand, ratoons are always more or less affected by scales, and this would seem to be an argument against the practice of ratooning, since the ratoon crop serves as a breeding place for scales and other insects, which find this crop much less vigorous than the plant cotton and therefore more favourable to their development.

The scales attacking cotton, *Lecanium nigrum* and *Chionaspis minor*, are well described in Mr. H. Maxwell-Lefroy's pamphlet, *Scale Insects of the Lesser Antilles*, Part 1, issued by this Department.

The Hibiscus Shield scale (*Lecanium nigrum*).

A moderately flat, oval scale, about twice as long as broad, with a narrow flattened margin. Colour, deep brown or black, smooth, shining, with numerous minute brown spots.

Chionaspis minor.

The female scale is flat, pear-shaped, with a yellow spot at the narrow end. It is white in colour, and differs also from the Orange Snow scale in being smaller. The male scale is white, with parallel sides and three parallel ridges, having a small yellow spot at one end.

Remedies: Scale insects can be held in check by the use of kerosene emulsion, whale oil soap or rosin compound, but ordinarily it will be found cheaper and more practical in the case of attack on cotton to remove the plants and start over again. It has already been said that ratoons are most likely to be attacked, and it will be very rarely, if ever, that first crop cotton will be so seriously affected as to make necessary either spraying for the scale insects or the destruction of the crop.

CUT WORMS.

Many crops while still very young are injured by cut worms. There are a large number of moths whose larvæ have the habit of living in the ground and during the night eating off tender young seedlings. Many different crops are attacked but at present only very few instances are recorded of cotton being thus attacked. The cut worms are the larvae of moths belonging to the family *Noctuidae*, a name given them on account of their habit of night-flying. They are not brightly coloured and the larvæ are all dark, with plain markings as is entirely consistent with their habit of living underground.

The species concerned in this work in the West Indies have not been determined, but they are probably closely related to the North American species, the commonest of which are species in the genera *Feltia*, *Agrotis*, *Plusia*, and *Noctua*.

Remedies: If the attack by cut worms is not severe it will generally be possible to kill the individual worms and re-plant the holes in which the plants have been eaten. They can usually be found just under the surface of the ground in the early morning, with the freshly cut plant lying on the ground or partly pulled under.

In the event of a severe attack by cut worms, they may be effectually treated by means of a poisoned bait, which should consist of freshly cut grass or other tender plant well poisoned with Paris green or other stomach poison. This bait should be scattered about in the affected fields in small piles, where it will be found and eaten by the cut worms.

GRASSHOPPERS.

Frequently the leaves of the cotton plants will be seen to be punctured with large, irregularly-shaped holes. These are especially noticeable while the plants are young, and long

before any caterpillars are to be found, even by very careful search. These holes are made by grasshoppers. Records are at hand of only one species feeding on cotton, and that is the common greyish grasshopper, *Schiztocerca pallens* Thunb., which is found in most, if not all, of the West Indian Islands. It is generally the adult winged insect that damages the cotton, as the breeding place of the grasshopper is generally an old field or pasture where the ground is not ploughed up or disturbed, and these are frequently so far away that the young, who cannot fly, do not find their way to the cotton. The damage done to cotton, so far, is very slight, although it is well known that when they are abundant they are capable of doing considerable injury to crops.

Remedies: The methods employed to deal with the cotton worm will effectually control the grasshopper attacks. If, however, this pest attacks the cotton while it is very small and before the cotton worms have begun to appear, a poisoned bait such as recommended for use with cut worms might be used with good results.

A very minute moth (*Ereunetis minuscula* Walsingham) was found in old cotton bolls in a field of ratoon cotton at St. Lucia. Specimens were submitted to Dr. L. O. Howard, Chief of Division of Entomology, United States Department of Agriculture, Washington, D.C. The insect was identified and the name given above was returned with the information that it is a scavenger which feeds on vegetable refuse.

In this case the larvae had bored into the cotton seed, and the fibre was entirely spoiled, but it may have been injured in the first case from some other cause.

BENEFICIAL INSECTS.

Two species of the lady-birds are common in these islands and they are frequently found in the cotton field. They feed in both adult and larval stages on plant lice and scale insects; and are of great benefit in assisting to hold these pests in check.

Cycloneda sanguinea L. is a small beetle, very hemispherical, and all red above except the head and thorax, which are dark with fine white markings. It walks very rapidly and flies swiftly but usually only a short distance in one flight.

Megilla maculata De Geer is more elongate than the preceding, the ground colour is more pinkish or pale-red, and there are twelve black spots on the wing covers. When these are closed together, there seems to be only ten spots, because two spots on each wing cover are exactly opposite the two corresponding ones on the other side, and they touch when the wing covers are brought together.

The eggs of both species are small, orange coloured, and are laid closely packed together and standing on end. The upper end is pointed. Rarely these eggs are scattered about on the leaf, but usually they are laid in a regular compact mass. The larvae are spiny, active, generally dark coloured with lighter spots. The head and thorax are rather broad, the abdomen tapers gradually to a point behind. The legs are

rather long. It is in this stage that these insects do a great deal of good by their habit of feeding on small pests. The pupae are naked, and are found on the leaves of the plants. They are of a pale orange colour with a few fine black spots and are rather conspicuous in contrast to the green of the leaf.

Observations are wanting as to the number of broods each year in these tropical islands and the length of time in each stage, but it is known that they increase with remarkable rapidity when there are plenty of those insects that furnish them food, and it is probable that the life cycle is completed in a short time.

The Lace Wing or Aphis Lion (*Chrysopa* sp.) is another insect beneficial on account of its habits of feeding on other and smaller insects. In fact this carnivorous habit is so well established that the eggs of this insect are attached to long stalks, so that the first one to hatch may not find and devour all the others, which is what would happen if they were all laid together on the surface of a leaf. These slender white stalks with the white egg at the top suggest the fruiting stage of certain fungi, and they are very likely to be found on any plants where plant lice are abundant.

The larvae are rather spindle-shaped with long, strong mandibles. They are very active and always hungry and will attack and kill any insect that is not too strong for them. Their jaws are so arranged that while the aphis or other insect is being held by them, the juices of the body are sucked out by means of grooves on the under side, and the husk, as it were, is cast aside. They thus differ from the lady-bird larvae which devour the body of the aphis.

The pupa is enclosed in a delicate white, pearl-like cocoon. The adult is a beautiful green fly-like insect with large lace-like wings, long, slender, antennae and bright, prominent eyes. The body is slender about $\frac{1}{2}$ inch in length, and the spread of wings is about an inch.

These small insects are of great value in assisting to keep down the smaller insect pests, and it may always be taken as a good sign when large numbers of them are seen flying about cultivated fields

The wasps, called locally, Jack Spaniard, cow bee and wild bee are frequently to be seen in cultivated fields and especially in the cotton fields infested with the 'cotton worm.' Two of these, the wild bee and cow bee (*Polistes* sp.) have been observed feeding on the cotton worm and other caterpillars, and it is probable that the Jack Spaniard and others may have this habit of eating caterpillars. At all events it will be better not to destroy their nests, unless actually obliged to do so, on the chance that they may possess this useful habit.

Since this article was written two species of parasites have been reared from pupae of the cotton worm at the Laboratory of the Imperial Department of Agriculture. One is a fly of the dipterous family Tachinidæ, commonly called Tachina flies. About forty specimens of this fly have been

THE COTTON LEAF BLISTER-MITE.

(Phytoptus sp.)

This so-called disease of cotton was first reported to the Imperial Department of Agriculture from Montserrat in July 1903. Specimens of cotton leaves were accompanied by letters from Mr. C. Watson, of Dagenham, and Mr. A. J. Jordan, giving an account of the appearance of the affected plants and stating that several acres of ratoons had been pulled up and destroyed on account of the injury done by this disease, which at that time was supposed in Montserrat to be of a fungoid nature. Examination by means of the compound miscroscope revealed a minute arachnid animal so much like the pear leaf blister-mite (*Phytoptus pyri* Sch.) of the northern countries that it was referred to the genus *Phytoptus*, even in the absence of technical descriptions of the generic characters.* In reply to these letters the nature of the disease was explained, and it was suggested that the destruction of the infested plants should be continued, as that seemed to be the most practical remedy. At the request of his Honour the Commissioner, the writer was directed by the Imperial Commissioner of Agriculture to visit Montserrat and investigate. A report of this visit was published in the *Agricultural News* (Vol. II, p. 309).

The present account will of necessity be, for the most part, an amplification of that report with notes on the microscopic study of the mite and the affected leaves.

Origin : The origin of the Cotton Leaf blister-mite is unknown. No record appears of the diseases and pests of cotton in Montserrat in the days of the cotton cultivation of the past, and there are now none who remember those days sufficiently well to say with certainty whether such a disease was then known.

Food Plants : Although a careful search was made among the wild plants, growing on the hills and uncultivated land, for plants with blister or gall-like growths on their leaves, and a number of such gall-like structures were examined, no plant was found affected with this mite. The 'volunteer' cotton, that is, native cotton growing without cultivation, is entirely free from it.

The most suspicious occurrence is the gall on the leaf of 'cushaw' (*Acacia arabica*). This is a compound leaf with very

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obtained up to this time. The second parasite is a hymenopterous insect, *Chalcis annulatus* Fabr.

*Specimens of leaves of cotton affected by the Leaf blister-mite were sent to Dr. L. O. Howard, Entomologist to the United States Department of Agriculture, who reports as follows :—

'The cotton gall mite is a new species of the typical genus *Eriophyes*, according to Mr. Banks, our expert. He will describe it as *Eriophyes gossypii* n. sp. Banks. The family to which it belongs is now called the *Eriophyidae*, but it corresponds exactly with the old family *Phytoptidae*, and *Eriophyes* is simply an older name for *Phytoptus*.'

fine leaflets, pinnately arranged, which frequently bear small rounded galls. These galls are entirely different from those on the cotton, being regular in shape, smooth, and with no epidermal hairs, which are so characteristic in the cotton blisters. In these galls, however, are found small animals very similar to the ones found in the cotton galls. They are slightly smaller, but evidently a species of *Phytoptus*. Similar galls on other leguminous plants were examined in Montserrat, but they did not contain any phytoptoid mites. Specimens of *A. arabica*, sent to the Imperial Department of Agriculture by Mr. Jordan, were in a better condition for study, and large numbers have been found in the galls. As this is a very common wild plant in Montserrat, it is possible that it is the source from which the cotton has been infested, and that other leguminous plants may be attacked by the same mite. It is difficult to say how far the specific nature of the plant may influence the nature of the gall formed, and how far the nature of the gall may affect the size of the mite. At all events, the gall-mite of *A. arabica* and the Leaf blister-mite of the cotton are very closely related, even if not the same.

Occurrence: This disease first became noticeable in fields of ratoon cotton at Dagenham estate, where it came to be so serious that the plants were pulled up and destroyed. Thirty-seven acres of ratoons were thus destroyed, and 8 acres of young plant cotton, that was planted either in fields that had just been cleared of the affected ratoons, or in or near the fields of ratoons while they were still standing. The mite has infested fields of cotton in other parts of the island, always appearing for the first time in a given locality on the ratoons and then spreading to other plants.

Previous occurrence: No record is known to the writer of the occurrence of any similar pest on cotton previous to the appearance of this disease at Montserrat. In 1893, there appeared in Louisiana a cotton mite which was closely related to the red spider, but not a blister-mite, and differing in many other ways from the *Phytoptus* found here.[4]

At the time the investigation was being carried on in Montserrat, Mr. Belling, Science Master at St. Kitt's, was investigating the same disease there, and on the return journey from Montserrat to Barbados, the writer discovered a small experimental plot of cotton at the Agricultural School at Union, St. Lucia, similarily affected. The cotton attacked at St. Kitt's was ratoon cotton as at Montserrat, but at St Lucia the plants were old, but not ratoons. These three places are the only localities so far known to the writer in which this disease has ever appeared.

Spread: Although the Leaf blister-mite occurred almost simultaneously in fields of ratoon cotton in different parts of Dagenham estate, and at other widely separated places in the island, the spread from these points of infection seems in every case to have been caused by the wind. Fields of plant cotton to leeward of infected ratoons were the first to which the disease was communicated and it always appeared in a narrow belt on the windward side.

In one case the ratoons and young plants were separated by a road and the disease had travelled across it to windward, while in another place two fields adjoining were separated by only the ordinary distance between the rows of cotton, the younger field being somewhat to windward, and the disease has been much slower to travel between these fields.

In an excellent account of the Black Currant Bud gall-mite, Mr. E. J. Lewis[5] suggested birds and insects as carriers of the mite, and the Cotton Leaf blister-mite may be spread by the same means.

Appearance of the disease: The first indication of the *Phytoptus* on the cotton plant is a slightly distorted or crumpled appearance of certain leaves. Soon after, the axillary buds are attacked and become so distorted that the lateral shoots, which should bear a large proportion of the crop, are unable to develop.

Leaf, stem, flower, pod and bracts surrounding the pod are all attacked, the roots apparently being the only part exempt. Sometimes a plant may have only a few leaves slightly distorted; again, every leaf and bud may be so badly deformed as to make it impossible for them to carry on their natural functions.

When this disease was first observed on the cotton in Montserrat it was called 'Junjo' by the labourers, because of a fancied resemblance to an early stage in the development of *Filaria* (elephantiasis). 'Junjo' is therefore the local name in that island, and perhaps the only vernacular name as yet given to it.

Examination of these distorted parts show that the first effect is the growth of a large number of adventitious epidermal hairs. These are unicellular, thick-walled, colourless, straight or somewhat bent or curved. This growth of hairs is evidently caused by the irritation set up by the mite, and it is among these hairs that it lives. The irritation increases and causes a distortion of the leaf, which finally produces a hollow gall or blister with the hairs inside. Galls on the other parts vary only so much as the different tissues make necessary, but these epidermal hairs are always present in large numbers. The galls on the leaf-stalk, stem and pod are not hollow like those of the leaf, but are merely clusters of hairs which furnish protection to the *Phytoptus*. In these galls the mite passes its life and lays its eggs. It is not known how many insects originally inhabit them, but enormous numbers have been found in the older ones, together with what appear to be eggs. As the galls become older they turn, in many instances, to a bright red colour and frequently give the leaves a reddish appearance; later still, they become brown, dry and corky. At this time the mites come to the extreme apex of the gall which is generally on the upper surface of the leaf. It is doubtful if the opening of the gall, which is generally on the lower side, ever closes entirely, but it sometimes happens that the gall opens at other places. They have been found with openings at the top, which is at the farther point from the mouth, but whether this was due merely to a shrinking of the tissues

producing a fissure, or whether the mite ate a way through, it is hard to say. At all events they were found in great numbers on the outer surface of the gall at this place. In one instance the mass of mites, collected on a gall about one of these openings was so large as to be plainly visible to the naked eye. If this practice of emerging at the top of the gall is a common one, it may account for the fact that the mite is distributed by the wind, as it would in this way be exposed to the best advantage for the purpose.

The cause of the disease : The animal that is responsible for this damage is a very minute arachnid, not a true insect, but more closely related to the red spiders, cattle-ticks and itch mites. It is somewhat bent, shuttle-shaped, tapering to both ends, and has two pairs of legs situated at the forward end ; the mouth-parts are formed into a sort of proboscis, but are probably adapted for biting and not for sucking. The legs and mouth parts form a group of appendages at the anterior end of the body. The body is minutely, transversely striated, nearly colourless, and bears several pairs of very slender bristles. Its length is ·10 to ·13 mm. and its diameter is ·04 mm. It is much too small to be seen with the naked eye, and can rarely be seen with the aid of the pocket lens. There is no metamorphosis as in the case of insects, the life cycle comprising only two forms—the egg and the mite itself—the latter probably varying but little in appearance from the time it is hatched till it is fully adult. Nothing is known of the life-history of this mite as to how many eggs are laid by each female, the length of time in egg, the length of time consumed in the life cycle, the mode of spread, and food plants other than the cultivated Sea Island cotton.

There are a number of closely related forms which are more or less injurious, some of which have a very wide geographical distribution, but for the most part each species is known to attack only one species of plant.

Remedies : Owing to the protection afforded by the galls in which the *Phytoptus* lives, the ordinary remedies are not effectual. Digging out and burning the badly affected plants, especially ratoons, is strongly recommended and is being practised on those estates where the disease has become established.

Several insecticides have been tried in Montserrat, but without apparent results. Whale oil soap solution, kerosene emulsion, lime wash and lime and sulphur have been applied as sprays, and dry lime and flowers of sulphur have been dusted on, both separately and in combination.

Mr. Watson, who has tried all these, writes that frequent rains interfered with the trials of the insecticides, and adds that hand picking of affected leaves seems to be the only practical remedy, and that that seems to give good results. But it must be done while plants are small and the infection comparatively slight.

Mr. H. H. Cousins, Government Analytical and Agricultural Chemist, Jamaica, who experimented with insecticides on the Black Currant Bud gall-mite (*Eriophyes* (Phytoptus) *ribis*

Nalepa),[5] found that the ordinary contact poisons were of little value, and the experiments, which he carried out with hydrocyanic gas fumigation, showed that only a part of the mites were killed by this treatment, which is very effectual with most insect pests.

REFERENCES.

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2. *The Mexican cotton boll-weevil:* F. L. Malley, United States Department of Agriculture, Farmers' Bulletin, No. 130.

3. *Insect Life*, Vol. VII, p. 314, 1895.

4. *Louisiana Agricultural Experiment Station Bulletin*, Second Series, No. 48, 1897.

5. *Journal of the South Eastern Agricultural College*, No. 11, 1902.

SEA ISLAND COTTON IN THE UNITED STATES AND IN THE WEST INDIES.

BY SIR DANIEL MORRIS, K.C.M.G., M.A., D.Sc., F.L.S., AND

MR. J. R. BOVELL, F.L.S., F.C.S.

In the previous pages of the *West Indian Bulletin* (pp. 195-286) information has been given in regard to the cultivation of cotton and kindred subjects for the guidance of planters in the West Indian Colonies. The points dealt with have been as follows:—the general system of cultivation adopted for cotton, both Upland and Sea Island varieties, in the United States of America; the origin and distribution of Sea Island cotton with an account of the improved sorts of that cotton obtained in recent years; the description of the methods suggested to be adopted by the United States Department of Agriculture for improving Sea Island cotton in South Carolina and part of Georgia and Florida; the recent revival of cotton cultivation in the West Indies with particulars of the efforts to cultivate cotton, on a commercial scale, at St. Kitt's, Antigua, Montserrat and Barbados during the year 1902; the agricultural chemistry of cotton, in which the composition of the plant with reference to the uses to which the planter and manufacturer may respectively put its several parts, to the draft on the land entailed by the cultivation and to the more economical and effective means of manuring cotton: then follow two interesting articles on the fungoid diseases and the insect pests affecting cotton in the West Indies with practical suggestions for dealing with them.

In view of the considerable extension in the planting of Sea Island cotton in these colonies during the year 1903, it was realized that it would be of great advantage to the members of the planting community, if fuller information in regard to the cultivation and preparation of this cotton could be placed within their reach as early as possible.

The Secretary of State for the Colonies approved of the Imperial Commissioner of Agriculture for the West Indies proceeding to the Southern United States to study the conditions under which Sea Island cotton was grown, and to prepare a report on the subject. The Commissioner was accompanied during his visit by Mr. J. R. Bovell, F.L.S., the Superintendent of Agriculture at Barbados.

The visit was made during September and October 1903. At that time the various operations of picking, drying, sorting and ginning the cotton were being actively carried on. The principal plantations visited were on James Island, near Charleston, South Carolina, and near Blackshear in Georgia. By the courtesy of the Hon. James Wilson, Secretary of the United States Department of Agriculture, valuable information was obtained at Washington, and Mr. W. A. Orton, an officer of the Department, was deputed to proceed to South Carolina and Georgia to explain the various experiments carried on with a view of improving the yield, length and strength of fibre, resistance to disease and adaptation to soil and climatic conditions of Sea Island cotton.

The various points on which information was obtained, likely to be of immediate interest in the West Indies, are contained in the following pages.

Before proceeding with the report itself it may be useful to review the present situation in regard to cotton and indicate the very exceptional circumstances associated with the industry at the present time. These are well stated in the following extract taken from 'Some impressions of a visit to the cotton-growing States of America' by George P. Foaden, published in the *Journal of the Khedivial Agricultural Society* (Vol. V, pp. 133-78)* :—

'At the present day, cotton occupies more attention in the commercial world than any other product, and we hear on all sides of the great endeavours which are being made to increase its production in those countries already growing it extensively, as well as to introduce it into new regions.

'It is the most important fibre which enters into the commercial life of the textile industry and this is more true to-day than formerly. It is universally used for the clothing of all nations, both rich and poor, and it would be difficult to name a commodity in wider use. Being cheap and easy to manufacture, it is clear why this is so. It is the only fibre which nature produces ready for immediate manufacture, and as long as its price, relative to that of other fibres, such as wool, flax, silk, etc., remains as at present, there seems to be no limit to its production and consumption for some time to come at least.

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* Mr. Foaden is Principal of the School of Agriculture in Egypt. He paid a visit to the United States with the view of making an inquiry into the cotton industry in May 1903. As he was there during the period when the cotton plants were under active cultivation, his observations under this head are of special interest and are freely quoted in this Report.

There seems to be no doubt, in fact, but that the consumption of cotton is increasing at a faster rate than its production. During the past three or four years the consumption has, in fact, equalled the production, and so tightly has the former pressed upon the latter, that cotton mills in England and on the continent have been forced into partial idleness on account of a shortage of the raw material. The world now needs a new supply of cotton, as it is generally accepted that a greater or less scarcity threatens us.

'It is well known to our readers that an association known as the British Cotton Growing Association has recently been formed for the purpose of encouraging the growth of the raw material in new territories. It is early, however, to estimate what the practical results of the efforts of the Association will be. It is asserted that American speculation is acting to the detriment of legitimate trade, this being possible owing to the demand pressing so tightly on the supply and the predominant position occupied by the United States as a cotton producer. It is beyond question, however, that the United States is consuming annually a greater quantity of its own cotton, and that the outside world is suffering from a scarcity. For these and other reasons, steps are being taken to find supplies of the raw material elsewhere and thus render Europe less dependent on American supplies.'

In common with other countries deep interest has been taken during the last three years in the revival of cotton growing in the West Indies. The first attempts in this direction were made by the Imperial Department of Agriculture at the Rivière Dorée Experiment Station in St. Lucia in 1900. These have since been extended into other districts. In 1902, the cultivation of cotton was attempted on a larger scale on estates at Montserrat, St. Kitt's and Barbados. At the close of 1902, it was estimated that there were about 600 acres under cotton in the Leeward Islands, St. Lucia and Barbados.

During the year 1903, under the influence of the encouragement offered by the British Cotton Growing Association, considerable efforts were made to extend the cultivation of cotton throughout these colonies. The following is an approximate estimate of the areas planted in 1903 : Jamaica, 15 acres; British Guiana, 20 acres; Trinidad, 50 acres; St. Vincent, 500 acres; Barbados, 1,200 acres; St. Lucia, 80 acres; Montserrat, 700 acres; Antigua, 400 acres; Nevis, 300 acres; St. Kitt's, 400 acres; Anguilla, 20 acres; Virgin Islands, 100 acres. In addition there were several areas placed under cotton on the share system by peasants at Carriacou, Union Islands and other islets in the Grenadines. The total area under cotton in the West Indies in 1903 was probably not less than 4,000 acres. The crop from this area is to be reaped early in January to April, 1904. Ginning factories have already been erected at St. Kitt's, Antigua, Montserrat, St. Lucia and Barbados. A large three-storied factory, containing eight gins and a press, on the plan of the best existing in the Sea Island districts of the United States, is in course of being erected by the Imperial Department of Agriculture at St. Vincent.

In order to test by actual experiment what varieties of cotton were best suited for cultivation on a large scale in the West Indies, seed was obtained of several sorts of long-staple cotton known as Sea Island, also of several sorts of Upland or short-staple cotton, as well as Egyptian, Peruvian and Marie Galante cottons (the latter from Carriacou). In some instances seed of the semi-wild cotton found in several of these colonies was planted for experiment purposes.

It is not yet possible to give the comparative results in regard to all these varieties. There can, however, be little doubt that Sea Island cotton is generally regarded as the most suitable for cultivation in these colonies. This was originally a native of these islands, but as now grown in the Southern United States it is considerably improved, both as regards its adaptability to cultivation and the length and quality of its fibre.

SEA ISLAND COTTON.

The origin and distribution of Sea Island cotton has already been discussed in the *West Indian Bulletin* (Vol. IV, pp. 199-201), its selection and improvement (Vol. IV, pp. 201-14), and its general cultivation (Vol. IV, pp. 215-24). See also Appendix C.

'This is without doubt the finest cotton grown in the world. It is grown in America on a few small sandy islands off the coasts of South Carolina and Georgia, and on lowlands near the sea in these States, as well as in Florida. It cannot be successfully raised inland as the quality greatly deteriorates. The plant is not a heavy yielder and the small amount of produce obtained has to be compensated for by quality. The origin of the plant is somewhat doubtful, and when first introduced into America it was entirely different to its present form. The standard of excellence at present reached has been obtained by a careful system of selection, as well as by the system of cultivation adopted. The fibre is very long, varying from 1½ to 2½ inches, is creamy brown in colour, but much less brown than Egyptian cottons. It is very fine, strong and silky, with a comparatively regular twist. The cotton is used for thread, lace-making and for very fine counts of yarn, from 120 and upwards to as much as 400, and even more in exceptional cases. Where a very strong fibre is required for heavy yarns, this cotton is also used, as for example for sail cloth, linings of bicycle tyres, etc. It is now employed for making mail bags in the United States. The leading market for Sea Island cotton is Charleston in South Carolina. This cotton, unlike the ordinary American cotton, which possesses seed covered with short lint and is white in appearance, has clean black seed similar to Egyptian and is ginned similarly to our cottons by the Roller Gin. Greater care is, however, taken in handling in order to put the cotton on the market perfectly clean; quality and cleanliness being the leading considerations. Quantity is a secondary consideration, and with the higher grades of cotton this should always be so, as when the quality deteriorates they simply fall into line with, and consequently

into competition with, the lower grades, of which there is a more abundant supply.'*

The characteristics of Sea Island cotton are as follows:—The plant should be from about 4 to 5 feet in height, and have numerous lateral branches springing from the base of the plant. The main branches should have short internodes with many branchlets, each branchlet having short internodes with bolls on each node. The bolls should open well so as to allow the cotton to be easily picked, be long in proportion to the breadth and be somewhat pointing. The seeds should be comparatively few and small. The lint should be fine and silky with the individual fibres nearly of the same length, and not less than 2 inches long. The methods to be adopted for obtaining improved varieties of Sea Island cotton, possessing the qualities above described, are discussed in the *West Indian Bulletin* (Vol. IV, pp. 201-14).

It is well known that the yield of lint from Sea Island cotton is less than that from any other kind, but on account of the length and quality of the fibre it is adapted to uses to which the other kinds are not suited, and its high market value more than compensates for the small yield.

There is no doubt, as stated by Mr. Foaden, that as the demand for finer and better fibres increases, there must be an increased demand for long-staple cottons. The production of Sea Island cotton is restricted to comparatively small areas and it is recognized that it will be much more difficult to increase the production of fine qualities than of ordinary cottons. It is also in favour of Sea Island cotton that the demand for it, and the closely allied Egyptian cotton, as shown by statistics lately published, has been steadily increasing during the last ten years.

It is improbable that the comparatively limited quantity of Sea Island cotton likely to be produced in the West Indies will seriously affect the market for long-staple cottons. The production of Egyptian cotton is about 500,000 bales, of Sea Island cotton from South Carolina, Georgia and Florida, about 50,000 bales annually. If we assume that in the West Indies, at the end of five years, about 30,000 acres will have been placed under cultivation in Sea Island cotton, the return from this area (at the rate of 300 ℔. of lint per acre) will not exceed 18,000 bales. Taking into account the increased demand that will, in the meantime, have arisen for long-staple cotton, there need be little, if any, apprehension as to the price of Sea Island cotton being maintained at such figures as will prove remunerative to the growers.

In confirmation of what is stated above it may be useful to place on record the following opinion recently expressed by

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*George P. Foaden in the *Journal of the Khedivial Agricultural Society*, Vol. V, No. 4, p. 152.

Mr. J. C. Atkins, F.C.A., Secretary of the British Cotton Growing Association :—

'The class of cotton grown in the West Indies is what is called the long-staple cotton. That is the best class of cotton grown, and the tendency in this country now is to use a better class of cotton, and unless you have some good production in the next few years we shall have just as bad a deficiency of long-staple cotton as we now have in American cotton. In the West Indies both the climate and the soil are suited for the growing of cotton. We have had cotton sent to the Association from different growers, and in every case I believe I am right in saying that they made 100 per cent. profit on the transaction. One grower sent his cotton, and I do not think the cost of the growing was anything more than 5*d.* per lb., but the price we remitted to him, after all expenses had been paid, was more than 10*d.* I do not say that that can be kept up always, but the cotton growers can always rely on a minimum of 9*d.*, and probably more. Cotton from Barbados is the very best cotton grown, but that cotton does not cost any more to grow than cotton at 5*d.* or 6*d.* Therefore I think there is a very great future before the cotton-growing industry in the West Indies.'

SEA ISLAND COTTON SOILS.

In Appendix A. is reproduced interesting information in regard to the physical features and the character of the soil in the Sea Islands of South Carolina. The best soil for cotton is described as 'a fine sandy loam.' This usually rests on a subsoil of yellow sand or yellow clay of fine texture and deepening in colour from yellow to red. These clays are said to give a yellow hue to the otherwise grey surface, indicating lands peculiarly adapted for the production of silky fibre of long-staple cotton. The analyses of two soils, (1) from the north east of James Island, furnished by Mr. Elias Rivers, represents the less sandy soil of the Sea Islands capable of yielding 300 lb. of long-staple lint one year with another; and (2) from Edisto Island famous for having produced the finest grade of Sea Island cotton and regarded as a representative cotton soil, will be found in this appendix.

A careful study of these analyses should prove of great service in selecting the best cotton soils in the West Indies.

We have already quoted from Mr. Foaden's report. We extract the following in regard to cotton soils, drainage, etc. :—

'The great variety of soils upon which cotton may be cultivated with success is remarkable. Within the immense cotton-growing district of the South are found, as would be expected, every class of soil from light sands to dense clays, from dry shallow soils to wet bottom lands. They are not all equally suitable, however, for cotton. On sandy soils the plants are small and the yield inferior, on heavier soils the yield is greater, but on the very heavy clays the plants are inclined to be coarse, and if they receive too much water (either in the form of rainfall or irrigation), they attain a large size and produce a small amount of fibre in proportion to their size. An ideal soil for cotton is considered to be that of a medium nature,

a sandy loam underlaid by a soil which is heavier or more clayey in nature, which will prevent the too rapid escape of water and the loss of manure. A soil of a medium nature also allows heat and air to reach the roots more readily than dense clays. The soil, however, should incline to clay rather than to sand. The question of soil is so intimately connected with other matters, and especially climate as affected by water supply, that it is impossible to consider them apart. In the United States the cotton crop is grown without irrigation; it is dependent on rainfall, and it is for this reason that it is so precarious. During the months of May, June, July, August and September there are, on an average, about 22 inches of rainfall in the cotton-growing States, and during these months rain falls on an average every third day.

'The daily range should be as uniform as possible during the growing period of the plant. There are two periods, as it were, in the growth of the plant: the first period is the vegetative period, and the second, the period of maturation. During the first period, the plant delights in a high and increasing temperature; any great and sudden change in temperature, or any prolonged period of 'fresh' weather arrests its growth. It is said in America that when the full period of vegetative growth is attained, that is to say, when the plant has stored up within itself all the material necessary for the production of fruit, a diminishing temperature is favourable, as well as a greater difference between day and night, as this tends to check any further growth on the part of the plant, and induces it to convert the food it has already accumulated into fruit rather than into new growth. . . .

'The question of drainage is one that demands considerable attention in many cotton-growing districts in America; it is, in fact, the great agricultural need in many regions. In the districts where Sea Island cotton is grown and where cultivation is carried to a high pitch of efficiency, planters are fully alive to the need of good drainage and to the harm which results from excessive moisture. In order to prevent water from becoming stagnant on their lands, open drains were at one time used, but in recent years they have been deepened and regular tile drains are in use. In conversation with the best planters we could at once gather the great importance they attached to the question of the influence of the water supply on the success or otherwise of the crop. The passage of water through the soil, instead of allowing it to stagnate, as we sometimes see it in this country after excessive waterings, is a matter of first importance with them. Although they are at the mercy of the elements for their supply of water, they at least make provision for removing any excess when it comes in the form of heavy rain, and they are fully alive to the damage which much water does, especially at certain periods of the plant's growth. When the plants are forming fruit, heavy rains are considered injurious; the act of forming fruit tends to retard growth. The plant has by this time practically stored up within itself sufficient nourishment for its fruit and we do not want to push growth. Naturally, water is necessary, but not in such quantities as to cause the plant to continue to grow rapidly. Growth, and the formation

and ripening of fruit, are as it were two opposite processes, and both cannot go on to their greatest advantage at the same time. Continued growth means diminished fruiting, and vice versa, consequently to apply much water to a cotton crop and to expect it to ripen early is to attempt the impossible.

FREQUENCY OF COTTON GROWING.

'In the Sea Island districts, cotton is grown every second year, and as a rule the land is allowed to remain fallow during the alternate year. The writer was particularly struck with this on James Island, which is situated a short distance from the coast of South Carolina. When the cotton has been picked, the land is allowed to remain untouched, and a rapid growth of bushes, weeds, etc., commences, which is kept down by pasturing cattle and sheep on the land. This is continued during the second year, and in the following winter the preparation of the land for the next cotton crop begins. This practice of allowing the land to remain practically fallow every other year was a great surprise to the writer, and the planters were closely questioned on the subject. The different conditions existing, however, between cotton growers there and the Egyptian cultivator must be borne in mind. The first point which would occur to us would be to demand why wheat or maize or at least some leguminous forage crop, such as clover, peas, etc., was not grown the second year. The immense areas of grain grown in the western States, and the fact that the United States is a great grain-exporting country, and consequently a cheap producer, leads them to look elsewhere than on their own farms for their grain supplies. Labour, it must also be remembered, is dear. The cultivators of Sea Island cotton merely raise sufficient maize to provide food for their mules, on which grain they are chiefly fed. Taking into consideration, therefore, the cost of growing grain and its effect on the land, leads them to ignore this culture. The non-cultivation of a leguminous forage crop, however, cannot be argued in the same manner. The writer thought that a crop of clover or peas might be cultivated with advantage and not only at a less cost to the soil than a crop of coarse weeds, but that the soil would really be enriched by the growth of a nitrogen-gathering crop.

'It seemed, however, to be the general experience, that the growth of a leguminous crop every second year did not conduce to a successful cotton crop, and that once in four years was as often as it could be grown with advantage,—that is to say, the rotation would be: first year, cotton; 2nd. year, fallow; 3rd. year, cotton; 4th. year, leguminous crop. When the leguminous crop was grown it was sown between the rows of the old cotton crop after picking was finished. The crop grown is cow peas or even garden peas for the market, which grow up and twine around the old cotton stalks. It is then grazed by cattle and trampled down, and the new cotton ridges are formed over the old hollows where the leguminous crop had grown. The idea regarding the frequent growth of a leguminous forage crop is certainly interesting. It is maintained that the quality of the fine Sea Island cotton suffers, and that ripening is

delayed and the yield diminished. The interesting point to notice, however, is that although such is maintained to be the case, yet nitrogenous manures, such as cotton seed meal, etc., are employed, for cotton.

PREPARATION OF THE LAND.

'Whatever system of rotation be adopted, there is one point on which perfect unanimity of opinion exists and that is the necessity for good cultivation, and the obtaining of a good tilth. . . .

'When the land has been suitably ploughed, the operation of making ridges or, as they are called, beds is commenced.

The question now arises as to the distance to be left between the ridges or beds. It may at once be remarked that although, generally speaking, cotton plants in America do not grow as large as they do in Egypt, yet the rows are not placed so closely together. Sea Island plants are comparable in size to Egyptian on very strong land, and in this case rows are made as much as $1\frac{1}{2}$ metres apart, that is to say, but little more than four ridges to 2 Kassabas. . . .

'The question of the most suitable distances apart to make cotton ridges is a many-sided one; we have to bear in mind, on the one hand, that to obtain the best results we must leave sufficient room for the perfect development of the plants, while on the other, that within proper limits more plants per feddan* mean more cotton. The question is, therefore, how far we can go in each direction with safety. Cotton, we know, delights in a hot atmosphere and plenty of sun, and we can, by planting at a sufficiently wide distance, provide the plants with more sun than they obtain under opposite conditions. Naturally, the most suitable distance at which to plant depends on the nature of the soil and the usual growth of the plant. Where the tendency is to produce much growth, a greater distance must be allowed than where the habit of the plant is smaller; in other words, the poorer the land the less the distance. It may at once be mentioned that in the States the question of the distance at which the rows are placed is considered of more importance than the distance left between the plants in the row. It is maintained that if the rows are sufficiently far apart, the plants may be close in the row. It is said, in fact, that it is sufficient if the plants get the sun one way. . . .

'There can be no doubt but that cotton planted in rows sufficiently wide apart to allow the sun to enter freely is less liable to disease than cotton planted closely, and much less likely to suffer severely from attacks of worms. The latter delight in dampness and shade, both of which are induced by close planting. . . .

'Although there may be minor differences in various parts of the country, yet the principal point aimed at is always the same, viz., to get deep tilth to enable the cotton roots to go deeply into the ground. The cotton plant has a tap root

* A feddan is equal to 1·1019 acres.

which will, under favourable circumstances, go down 3 feet or more into the soil in search of food and moisture. The deeper the soil is stirred the deeper the roots will go, and consequently the greater the feeding area. By the operations of culture already mentioned, the soil is left in a loose friable condition, very suitable for the reception of seed. As the land is left fallow some time before cotton planting to enable the ordinary atmospheric agencies to act upon it, the soil does not turn up in that lumpy condition which one sees in Egypt, when Berseem lands are being ploughed up just previous to cotton planting, but it is in such a condition that in passing the plough between the furrows, the earth is easily thrown up to form the ridges and falls naturally to form the sides in a finely divided state.

'High ridges are in favour, as they promote drainage. When excessive quantities of water fall they act as a drainage system, the water very speedily running off so that no pools are left standing in the field. . . . .

'It has been mentioned previously that cotton is often grown successively on the same land: in this case the cultivation is practically similar to that indicated. The plough is first passed down the hollows between the old ridges, and this is done a second time to provide deeper labour. The manure is then spread along these hollows, and the old ridges are then split with the plough and the soil turned in over the manure by successive ploughings. It is seen, therefore, that this year's cotton rows are over the hollows of last year's cotton, so that any given strip of land is allowed to rest partially and to grow cotton in alternate years The practice of spreading the manure in the manner indicated is economical of manure. When a large quantity is available there does not seem, according to very extensive experiments which have been made, any advantage in this method compared to applying it in the ordinary manner, viz., broadcasting. Where, however, the quantity available is small, there seems to be a distinct advantage in spreading it along the furrows, and forming the cotton ridges immediately over it. Sometimes a light plough is passed along the line of manure to mix it with the soil before it is covered. . . .

SOWING.

'Assuming the land to have been treated as described, we are now brought to the operation of planting. This generally takes place from the middle of March to as late as May 1, according to the climatic conditions of the various districts. Whatever the date may be, it is generally accepted that, within the limits of the district, the earlier the cotton is sown the better, and it is generally agreed that in the case of early sown cotton, the seed should be sown shallow, for as the soil is generally cooler then, the seed has, when not planted deeply, more warmth for germination. As a general rule, it may be accepted that any crop, if sown early, within its proper limits, will give better results than if sown late, and this is certainly true of cotton.

'Early sown cotton grows more slowly and regularly and we think branches better. It experiences in the young stages a less forcing temperature, and there is not that tendency to shoot up which is seen in later planted cotton. This is said to be pronouncedly the case in some districts in America where early planting is looked upon as one of the remedies for excessively coarse growth. The yield is also greater in the case of earlier planting, on account of the longer period of growth, and the fact that a greater proportion of the cotton is gathered before adverse climatic conditions affect it in the autumn.

PLANTING.

'This is done on the top of the bed or ridge and not on the side as in this country, this difference being accounted for by the fact that irrigation is practised here while in America, as already explained, the crop is dependent on rainfall.

'A shallow furrow is first opened on the top of the ridge about 2 or 3 inches deep, the seed is deposited and covered by 1 or 2 inches of soil. These operations are performed by a "cotton planter" which is drawn by a mule in a similar manner to an ordinary plough. A man and a mule can accomplish from 6 to 8 feddans per day, the sowing being done with great regularity. The use of the planter economizes seed, deposits it more evenly and produces a more regular stand. Although the planter performs the whole of the operations involved at one stroke, as it were, yet many open a shallow furrow along the top of the ridge (exactly over the fertilizer) with a light plough. The planter follows behind it, depositing the seed regularly and covering it up lightly by means of two shoes behind the planter, or a board which is attached to it. The planter is similar to a wheel barrow, provided with a seed box. Attached to the wheel is a crank connected to a lever attached to the seed box. The reciprocating movement given to the lever opens and closes alternately the seed outlet on the box, the slide keeping a constant delivery of seed by moving backwards and forwards.

'The small negro cultivator does not employ a planter. He opens a furrow on the top of the ridge and the seed is deposited through a tin tube, about 5 or 6 feet long, with a funnel at the upper end. The seed is carried by the negro in a bag suspended from his shoulder, and the tube is fed by hand through the funnel, the lower end of the funnel resting in the line where the seed is to be deposited. The seed is subsequently covered by drawing a harrow, a wooden block or a board over the land.

'On very rich land, where only very little manure is employed, the seed and manure are sometimes deposited together, that is by the same planter, but this can only be practised where very little manure is used as there is danger in bringing the seed and manure in contact with each other. Generally speaking, there is not much advantage in this plan, the only gain being the saving of one operation.

'Originally, before planters came into use, sowing was done in practically a similar manner to that now adopted in Egypt. Places were opened in the ridge with a hoe

at more or less regular distances and the seed dropped into each hole and covered with a hoe. The work was done by female labour, one feddan being accomplished per day by each woman. This requires a much greater quantity of seed than when the planter is used, while it is not deposited so evenly, some seeds being much deeper than others.

'With the cotton planter, seeds are deposited 1 inch apart in the row, the plants being subsequently thinned to the required distance. The question of the selection of seed for planting is one of very great interest, in fact, it is one that cannot be over estimated. The choice of good seed is an essential to the production of good-staple cotton.'

WHITE AND COLOURED PLANTERS

In regard to the present relations existing between the white and coloured planters and the system of letting land prevailing in the Sea Islands and other cotton-growing districts, we take the following from the Report by Mr. George P. Foaden already referred to :—

'The renting of small farms on what is known as the 'share' system is extremely common. The former large plantations are divided up, and both white and negro planters occupy these small farms on one of many bases of contract which will be referred to presently. . . .

'Where the white population is the largest we find the largest farms and a smaller proportion of them let. Where the negroes are more numerous we find a greater number of small farms of 50 feddans or less, and more of the farms are rented. As a general rule, however, we may say that in the cotton belt (*a*) farms are decreasing in size, (*b*) those of 50 feddans and under are becoming more numerous, (*c*) owners occupy a smaller percentage, and consequently a greater number of farms are being rented.

'In the case of the majority of farms which are rented, the tenants pay as rent a certain proportion of the produce. As can be well understood a great many systems are in force. These depend on many circumstances, such as whether the owner provides manure, mules (which are employed for labour) or not, and also on the quality and location of the land. The average in a number of States is that from a quarter to one-third of the crop is considered equivalent to the rent, that one-third is equivalent to the supply of manures, ploughs, animal labour, etc., while from one-third to five-twelfths are left to the tenant for his labour in raising the crop. Many variations are in vogue. For instance, in some cases the tenant pays one-fourth of the crop for the use of the land and meets all expenses of cultivation himself; in others, the owner of the land provides manure, implements, food for mules, etc., and claims one-half of the crop ; in others, the owner, as already mentioned, provides everything except labour, and claims two-thirds of the crop. The value from an economic point of view of such a system is very doubtful, but it is very questionable if, under any other system such immense crops of cotton could have been raised in the United States. . . .

'The negro cultivator, as might be expected, is not as successful as the white planter; he gives as a rule but very little attention to the improvement of his land and to the use of modern implements and manures. The cultivator who possesses sufficient capital to pay his way without having to resort to the money-lender (directly or indirectly) can make cotton growing pay, and it is currently said that in such a case, a planter (tenant) can by working only two days per week throughout the year, raise sufficient cotton to provide for the support of himself and his family. Settlers in new districts with a little capital seem to find a good opening in cotton cultivation, but small planters who begin the year by guaranteeing some portion of their crop, either to pay their rent or for manures, household supplies, etc., do not make the best of their land. Indirectly it leads to unnecessary expense in the cultivation of their cotton and thus raises the cost of production. The merchant charges high prices for supplies, an excessive interest on loans and the cultivator is prevented from adopting improved systems of culture or from taking that interest in his work which an unfettered man would. Purchasing on credit is very prevalent among small cultivators, and the rate of interest is often enormous. The consequence is that they often undertake work they cannot make profitable. The number of workmen thus available on land where really good cultivation is practised, is diminished, while a premium is placed on poor culture

'This really has raised the rented value of land; the owner is aware of the risk he has to run, and land, as already mentioned, is often rented for 40 per cent. of its purchase price. This has been one of the results of the splitting up of the land, into small farms, a tendency which in other respects is excellent. Bad cultivation often results, and this, further stimulated by excessive credit, has thrown land out of cultivation. The greater the facilities which are given for credit, the greater the tendency to rent land, which under such circumstances is, of necessity, badly cultivated. The land becomes impoverished, the owner suffers as well as the tenant, not only in this respect but also because labour which he could profitably employ is, no longer available. These conditions are, however, gradually changing, and the great industrial developments which are taking place in the South will have far-reaching effects. Great improvements are taking place in cotton cultivation. Many years ago, the virgin soil was cultivated and when it showed signs of exhaustion a move was made to fresh land. Now, however, conditions are entirely altered, and by means of better cultivation the use of manures, etc., the heavier yields obtained per feddan greatly reduce the cost of production. Black labour is becoming more reliable, and land is rapidly increasing in value. The economic conditions, however, are such that it is the small thrifty farmer, working on his own land, who obtains the best financial results, and owners of large tracts. It is said that under favourable conditions, cotton can now be produced with greater economy and probably with more profit than at any previous period. The great

railway extension which has taken place has brought most farms within reasonable distance of communication. Capital has accumulated, and the rate of interest charged to planters both white and negro, is diminishing, and many obtain no credit or advances at all. As has been previously mentioned, however, the labour difficulty is very great and militates against any very rapid extension in the total production of cotton. The prospects of the American cotton planter are however much brighter than they were some years ago.'

SEA ISLANDS OF SOUTH CAROLINA.

As in these pages numerous references are made to the Sea Islands of South Carolina, it may be useful to give a brief description of their physical features and climatic conditions in relation to the cultivation of cotton and other crops.

The Sea Islands form an archipelago stretching from Charleston down the coast as far as the Savannah river. The principal islands where cotton growing is an established industry are James, Edisto, Wadmalaw and John's. The smaller islands are St. Helena, Lady's, Paris, Spring, Port Royal. The total area of the four larger islands is about 100,000 acres. All these islands may be regarded as forming one or more deltas at the mouths of several rivers flowing east from the highlands of South Carolina and adjoining States. They have been built up in the course of ages by the alluvial deposits brought down by these rivers, banked up by the force of the Atlantic waves. In the creeks that separate or intersect the several islands, the tides (and flood waters from the interior) sometimes flow with considerable force.

The climate is sub-tropical. The islands lie almost in the same latitude as Bermuda. The Palmetto palm is a striking feature everywhere. On that account South Carolina is commonly known as the Palmetto State. Other conspicuous plants are the Cherokee rose (*Rosa lavigata*) and in gardens *Camellia japonica*. The summers are sometimes very hot, while in winter frost is not unknown. In exceptional years the thermometer for short periods indicates several degrees of frost. During our recent visit, in the early part of October, there was a sudden fall of temperature caused by a strong north wind, which transported us at almost a moment's notice from a warm summer climate into that of mid-winter.

In order to furnish more precise particulars we quote the mean temperature (degrees Fahrenheit) for each month at Charleston as shown in the charts included in the *Monthly Weather Review* issued by the United States Department of Agriculture for the year 1901 :—

January ...	50	July ...	80
February ...	47	August ...	80
March ...	56	September ...	75
April	57	October ...	65
May	72	November ...	53
June	75	December ...	47

There is a considerable range in the daily and monthly temperatures. The highest maximum temperature for 1901 was 95° F., the mean maximum 68° F. The lowest minimum temperature was 10° F., the mean minimum 49° F. The rainfall for the year 1901 was 32·70 inches made up as follows :—

January ...	2·25	July ...	5·53
February ...	3·58	August ...	4·95
March ...	2·40	September	·40
April	1·64	October	·86
May	4·30	November	·79
June	4·15	December	1·85

It will be observed that the rainfall is highest during the period when the cotton plants are growing, viz., from May to August; and lowest when the crop is ripening from September to November.

The vicissitude through which the Sea Islands passed immediately after the Civil War is graphically told in the following extract* :—

'Every one who is acquainted with the subject knows that the landed proprietors of the Sea Islands were, in years gone by, the wealthiest men in the State; that they lived like barons, surrounded by their vassals, upon their estates, and by their wealth and social position wielded no small influence in the political affairs of the Commonwealth. It is equally well known that upon them fell heaviest the evil results of the war, leaving them at the close of that disastrous struggle shorn of all save their lands and houses. To many not even the shelter of a home remained, and the soil of their ancestors was in the possession of their former slaves. In May 1866, through the interposition of the Federal Commanders, the rightful owners were restored to the possession of their estates but they were not in a position to resume, with any chances of success, their planting interest. They had no capital, and the negroes were bitterly opposed to them. With an energy and a perseverance, however, which, when viewed in the light of the surrounding circumstances, seem almost incredible, they succeeded in securing labour, although at very high rates of wages. They struggled also under another disadvantage. They had during their five years' absence, lost much of their agricultural knowledge and found it exceedingly difficult to adapt themselves to the new order of things. Fortune favours those who help themselves, however, and the first year's crop was both large and profitable. The lands, after a rest of five years, were rich and fertile, and yielded an abundant harvest. Cotton sold from $1·50 to $2·00 per ℔., and everything seemed to foretell a speedy return to the halcyon days of yore. But fate willed otherwise. With the year 1867 came disasters in every form. To add to the labour troubles, the season was unpropitious. Rain fell for weeks at a time, rotting the crops, and bringing with it the destructive cotton worm, which greedily devoured the scanty yield that remained.

'The years 1868, 1869 and 1870 were no less disastrous.

* Charleston *News & Courier*, April 22, 1880.

Everything was at its lowest ebb and hope had fled. But the darkest hour is before the dawn, and so it proved with regard to the affairs of the Sea Islanders. Finding that they must make a new departure in order to save themselves from utter ruin, the aid of science was sought, and the mode of cultivation was changed. The planting of large tracts of land was discontinued and by thorough drainage and high cultivation and fertilizing it was hoped to make an equivalent if not greater yield.'

James Island although the smallest in area has of late years come to be looked upon as probably the most important of the Sea Islands. It is directly opposite the City of Charleston at the junction of the Cooper and Ashly rivers. It is half-moon shaped, and is 9 miles long, and varies in width from ½ mile to 7 miles. It contains 12,000 acres consisting of open fields, pine land, dense thickets and swamps. The white people are about 1 in 30 of the total population. The others are black or coloured. To the planters of James Island is said to belong the credit of adopting and carrying into successful operation a system of cultivation which has entirely changed that hitherto followed in the Sea Islands. They are regarded as the pioneers, who with indomitable energy established a system of under-drainage, which, while it increased the productiveness of the land already under cultivation, enabled other areas to be reclaimed and planted with cotton. Amongst the prominent proprietors of cotton plantations in James Island are Mr. H. W. Hinson, Mr. Elias Rivers, Mr. Lawton and Mr. Seabrook.

Edisto Island is situated about 40 miles to the south-west of Charleston, opposite the mouths of the North and South Edisto rivers. In form it is irregular and indented by numerous creeks. It is 12 miles long and in the widest part between 4 and 5 miles broad and contains 28,811 acres. The surface is generally level. The slightly higher grounds consist of a light sandy soil. The low grounds or bottoms consist of a stiff clayey soil. In the days of the early settlers rice was the chief industry, later indigo was taken up and afterwards cotton. The population in 1880 consisted of 300 white and about 3,800 blacks. The coloured people are said to own between 4,000 and 5,000 acres, and it is estimated that they raise two-thirds of the cotton produced on the island. Corn is grown in about the same quantity as cotton, and hogs and cattle are raised for domestic use. Under-drainage has been adopted at Edisto Island on exactly the same lines as at James Island. Great stress is laid on the use of manures. Even twenty years ago the quantity of fertilizers applied *per acre* was as follows :—fish scrap, kainit and acid phosphate, 250 lb. each, cotton seed 40 bushels, bushes 8 cords. Some change has been adopted since that time especially in the use of compost and pen manure; but high manure is still regarded as a necessity in order to obtain large and reliable crops. Also the plough has largely taken the place of the hoe.

Wadmalaw Island lies to the east of Edisto. It is bounded on the south by Bohicket river, on the West by Edisto river and on the north by Wadmalaw river separating it from the mainland. The island is 9 miles long with a width ranging

from 4 to 6 miles and contains an area of 16,000 acres. In 1880, the population consisted of 2,000 coloured people and 165 whites. The soil is very similar in appearance and character to that of Edisto Island and is made up of alluvial deposits. Where under-drains are not used the system of open ditches has been resorted to.

John's Island is by far the largest of the Sea Island group. It is horse shoe in shape, 10 miles across and 32 miles from point to point. It contains 40,000 acres. Out of this about 18,000 acres are arable, the rest being pine and swampy lands. The most fertile lands are on the outskirts along the coast, the interior consisting of an impenetrable swamp. In 1880, the area planted in cotton was about 4,500 acres.

SEA ISLAND COTTON ON JAMES ISLAND.

On James Island cotton is replanted every year. Where a cotton field is to be replanted the following year, the old plants are broken down and levelled early in February by means of a hollow wooden roller, 5 feet in length and 3 feet in diameter, which is drawn over the fields. Where farm yard manure is used, it is placed in the old trenches, and often at the same time a quantity of chemical fertilizer is applied. Formerly the manure was covered by drawing the tops and sides of the ridges of the previous year over it with a hoe. This was termed 'listing.' Recently, however, the practice of covering it in with a plough has been adopted. Over this manure, portions of old plants, weeds, etc., a roller is now passed to compact the whole mass. Later on, in the centre of the beds or ridges thus formed, which are 5 feet apart, the seeds are planted 18 inches to 20 inches apart. It is claimed that if cotton is planted closer, the plants do not get sufficient light and air for the lower lateral branches to produce their maximum yield. Cotton is usually planted by three labourers: one chops the holes, the second drops in a small handful of seed, and the other carefully covers the seed with a hoe. Owing to the number of seeds sown, cotton rarely requires supplying. As soon as the plants have grown, the weeds are hoed up. At the second weeding, which takes place when the plants are about four weeks old, some of the seedlings are thinned from the bunches. This thinning is continued at each weeding until only one or sometimes two plants are left to each hole. When the plants are about six weeks old, a plough is run between the rows and the loose soil drawn up by hoes around the base of the plants to support them. This 'moulding' of cotton plants, as it is called, is a very necessary process, especially in districts exposed to strong winds. In such districts it is also desirable that head-rows of pigeon peas and guinea corn be planted to shelter the cotton plants. In about seventy days the first flowers appear; in about seventy days more the bolls open. At this time, the plants are from about 4 feet to 5 feet high.

PICKING COTTON.

Cotton should not be picked until the bolls are fully open and the boll-lobes somewhat slightly fluffy. In the process of picking, each boll is to be firmly held in the left hand; and

with the thumb and first two fingers of the right hand the whole of the seed-cotton should be extracted in one pull. Care should be taken that no trash or particles of pods, leaves, etc., adhere to the cotton. At this stage such particles are easily removed; but once they are allowed to become mixed with the cotton in bulk they cause considerable difficulty and expense. As can be easily understood, if a picker has to make two pulls to extract the cotton, he takes twice as long as if he completed the operation at once, and so only picks one half the quantity that he ought. It is therefore desirable that those who direct labourers when picking cotton in the West Indies, should impress on them the necessity of extracting the cotton with the fewest possible movements of the hands and with no injury to the plants.

In South Carolina cotton is usually picked by women and children, who carry bags, 2 feet long by 18 inches wide, suspended round their necks, to place the cotton in. As soon as the bags are full they are usually emptied on osnaburg sheets, 2 yards square. When there is sufficient cotton on these sheets they are folded across and the opposite ends tied together. Sometimes baskets are used to receive the cotton in the fields. The sheets are usually found more convenient for the purpose. The cotton is then weighed and loaded on carts to be taken to the store-house. Picking cotton is always paid for by weight. The operation requires a little practice, but the picker soon learns the knack of extracting the contents of the bolls. An adult picker, who is expert at the work, picks from 100 ℔. to 150 ℔. of seed-cotton per day. Children of twelve years old pick from 20 ℔. to 30 ℔. per day.

TO ESTIMATE THE YIELD OF COTTON LINT PER ACRE.

In the Sea Islands, the yield of lint is estimated from the number of bolls on the plants. The bolls on a number of plants of moderate size are reckoned and the average obtained. For every fifteen bolls, where the plants are in rows 5 feet apart and 20 inches apart in the rows, the yield is usually about 100 ℔. of lint per acre. Of course this varies slightly with the variety of cotton and with the yield of lint per 100 ℔. of seed-cotton. On the average 300 ℔. of lint are obtained from 1,100 ℔. of seed-cotton. Sometimes, however, where the variety has large seeds and where the seed-cotton has been kept for an unusually long time, as much as 1,500 ℔. is required to yield 300 ℔. of lint.

DRYING COTTON AND PREPARING IT FOR THE GINS.

After the cotton is taken to the store-room, it is examined either the same day, or the first thing the next morning, by the pickers who take out all bits of bolls, pieces of leaves, etc. The cotton is then spread on platforms or 'arbours' to dry. After it is sufficiently dried, it is assorted and if necessary, whipped. Assorting cotton is taking out, with great care, all immature and stained bolls, bits of leaf and motes. Whipping cotton is striking handfulls of the seed-cotton with a whipping motion on a $\frac{5}{8}$-inch mesh galvanized iron wire netting strained over a frame, 3 feet long, 2 feet wide and 6 inches deep. During this operation, the boll-lobes are more fully opened and any

extraneous matter, such as particles of soil, sand, etc., passes through the meshes. Whippers should prepare 300 lb. of cotton per day. It is desirable to mention that where the cotton has been carefully picked in good order and is free from all trash and leaves, whipping is not absolutely necessary. It is only badly picked or 'weathered' cotton that should require to be whipped. When the cotton is not properly prepared before it is sent to the ginneries, a charge of $3·00 per 1,200 lb. of seed-cotton is usually made for picking, assorting and whipping it.

After the cotton has been dried and prepared, it may be allowed to remain some time before it is ginned, in order that the lint may absorb a little of the oil from the seed. It is thought that this adds to the silky lustre of the fibre.

On James Island, where there are comparatively small factories, but all driven by steam, as soon as the cotton is made ready to be ginned, by assorting and selecting as above described, it is tied up in osnaburg sheets, 3 yards square, and sent to the ginnery. On the mainland, where there are large ginneries operating about thirty gins, the cotton is usually conveyed from the plantations to the factories loose in railway waggons. From these waggons, the cotton is drawn up to the top story of the factory through large tubes from which the air is exhausted by means of a revolving fan.

GINNING.

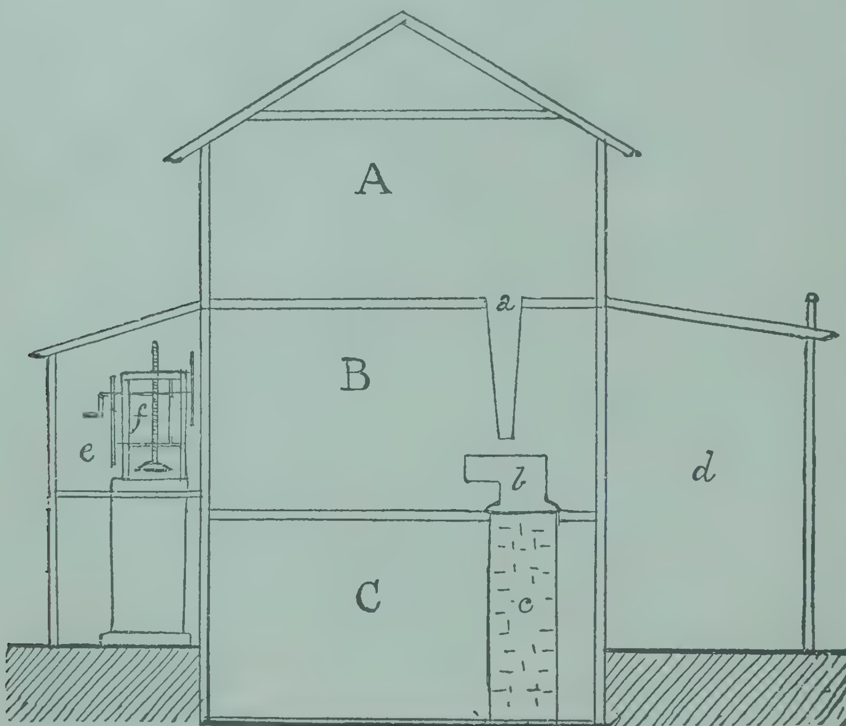
On the arrival of the cotton at the factory, it is again weighed, to test the loss by drying and whipping, and hoisted to the top story of the building known as the cotton loft. The cotton is then fed into shoots which pass through the floor just over each gin. While the cotton is being put into the shoots, the women or boys in charge remove any bits of leaves or discoloured cotton which may have escaped the pickers and assorters. The object of supplying the cotton to the gins through the shoots is that in case of fire it is not readily ignited. From the shoots the cotton is drawn out and fed to the gins as required. Behind each gin there is an endless conveyor about 5 feet long on which the lint falls as it comes from the roller. On each side of this conveyor, a woman usually stands to pick out any motes or stained cotton which may have passed through the gin with the lint. The conveyors, it may be mentioned, are driven by belting from the main shaft. The lint, which should now be quite white and free from impurities, is taken to the baling-room. Care is taken to remove the lint from the neighbourhood of the gins as fast as possible in order that in case of fire there may be very little of it left to be burned.

GINS.

The gins for long-staple cotton, almost universally used in the Sea Islands, are Macarthy Single Action, Single Roller gins made by Messrs. Pratt Bros., Messrs. Dobson & Barlow and Messrs. Lees, of Oldham, Lancashire. These gins are, however, modified, after being received, to suit local requirements. Specimen gins, so modified, are now at the Central Cotton Factory at St. Vincent. The gins should be firmly placed on a solid masonry foundation and be perfectly level. In the Sea

Islands they are usually placed on thick brick walls with arches between.

In setting a gin ready for working the following points should be carefully attended to:—First, the leather-covered



AN OUTLINE SKETCH OF A SECTION OF A THREE-STORIED COTTON GINNERY.

A. Cotton loft into which the seed-cotton is received from the plantation after it has been assorted. The cotton is spread on the floor and, if necessary, dried on the roof of the verandah (d). Afterwards it is delivered through an opening (a) in the floor by means of a shoot immediately over the gin. (b)

B. The gin room showing the position of the gin (b) resting on a solid masonry wall (c).

C. The power and seed room. The shafting and pulleys for operating the gins are attached to brackets at the base of the masonry wall (c). The belting passes upward through the floor and is attached to the gin (b). All the seed as it leaves the gin passes through an aperture in the floor into the basement.

(a) shoot for conveying the cotton from the cotton loft to the gin; (b) cotton gin firmly attached to a solid masonry wall (c); (d) a wide verandah on the roof of which cotton is dried; (e) press room with (f) screw press worked by hand-power for baling Sea Island cotton; this may be placed in a separate room as in sketch or at the end of the gin room as found convenient.

roller should be exactly parallel to the frame carrying the 'doctor' knife. Then the bevelled edge of the doctor knife should be placed against the roller and in such a position that the edge of the bevel presses on the roller a little more than the heel. The edge of the doctor knife ought to be opposite the centre of the roller or slightly above it. The beater should then be set so as to pass the edge of the doctor knife $\frac{13}{16}$ of an inch on its upward stroke, and the same distance on its downward stroke. In other words, the length of the stroke of the beater in front of the roller ought to be $1\frac{5}{8}$ inches. This should allow sufficient space for the cotton to be brought into contact with the roller. In some instances the beater shaft is raised higher than when sent out from England, so that the arc formed by the beater is equi-distant from the roller when at its highest and lowest points, and nearest to the doctor knife when passing its edge.

The spiral grooves of the roller should not be more than $\frac{1}{16}$ inch deep, and should be made on the edge of the flesh side of the walrus hide. Care should be taken that the roller has

been turned true, and that it is always the same distance away from the doctor knife along the whole of its length.

The leather on the roller usually remains in good condition for a sufficient time to clean about 100 to 125 bales of lint. After that period it will probably require to be renewed. An extra roller should always be ordered with each gin, so that the work of ginning may not be interrupted. The rollers are covered with a specially prepared walrus hide. This is said to cost in London about 3*s*. per ℔. It requires about 18 ℔. of leather to cover a single roller. During the present season it will probably be found more convenient to order extra rollers from the makers than attempt to cover them in the West Indies.

On many of the gins in use in the Sea Islands a brush is adjusted in place of the wooden or iron bar which hangs against the back of the roller to prevent the lint from being carried round with the roller, and so causing what is known as 'back lashing.' When 'back lashing' occurs it is useful to damp the roller by applying a wet towel to it while in operation. 'Back lashing,' if not immediately attended to, may cause the doctor knife to be forced outward until it comes into collision with the beater. The brush is attached to the frame of the conveyor behind the gin and fixed in position with a thumb screw and slotted angle iron so that it can be properly adjusted. Before the gins are used 'links' (connecting rods attached to the beaters) of a different construction are often substituted for those sent out with them.

In almost every instance, the gins are driven by two belts from the main shafting. One drives the roller at about 140 to 175 revolutions per minute, while the other operates the beater at about 850 to 900 revolutions per minute. *The longer the staple the slower the roller ought to turn so as not to break the fibre.*

FIRES.

Owing to cotton being inflammable, fires sometimes occur in the factories during the process of ginning, and many precautions have to be taken to prevent them from spreading. Some of the buildings are lined with tin or galvanized iron; others have the insides of the factories painted with fire-proof paint. In some instances it was observed that a pipe from the boiler entered the ginning room, and in case of fire all windows and doors were immediately closed and the room filled with steam. In most factories buckets containing an osnaburg sheet soaked in water were suspended by each gin, so that in the event of the cotton taking fire, the wet sheet could at once be thrown over the flames. At all the best factories water under pressure was laid on, with a hose always ready for use.

BALING.

From the ginning room the lint is taken to the baling press, which is sometimes in a separate room. For Sea Island cotton the press is entirely different from that used for Upland cotton. In the Sea Islands it is usually worked by hand. In one large ginnery in Georgia it was observed to be worked by steam. The construction of the hand-power press in which the

lint is pressed into a large sack by a plunger is as follows: The upper portion of the press, which contains the rack and pinions for raising and depressing the plunger, rests on the floor. Just beneath the plunger, a hole is cut in the floor, slightly smaller than the size of the bale. In this hole the top end of the bale bag is passed and tacked around an iron ring, slightly larger than the hole, which thus keeps the top of the bag suspended. Underneath the bale-bag on which it just rests, there is a platform suspended by four iron rods from the base of the press. This platform can be lowered or raised by means of nuts with handles working on threads run for some distance on the rods. The bale bags, which are $7\frac{1}{2}$ feet long, are made of Dundee sacking. Two qualities of this sacking are used—one which weighs 2 ℔. per yard, and the other, which is thicker, $2\frac{1}{2}$ ℔. per yard.

As soon as the bale-bag is filled to about one-third of its length, the plunger is lowered into the bag and the lint pressed. The plunger is then allowed to remain in the bag on the lint until the next lot is ready, when it is withdrawn and the lint inserted. This operation is continued until the bag is full, when it weighs about 400 ℔. Before the bag is put into position to receive the lint, a handful of cotton is put into each corner at the bottom and an 'ear' made so that in lifting the bale the workmen have something to hold by. 'Ears' are also made at the corners of the bag when the bale is being sewed up.

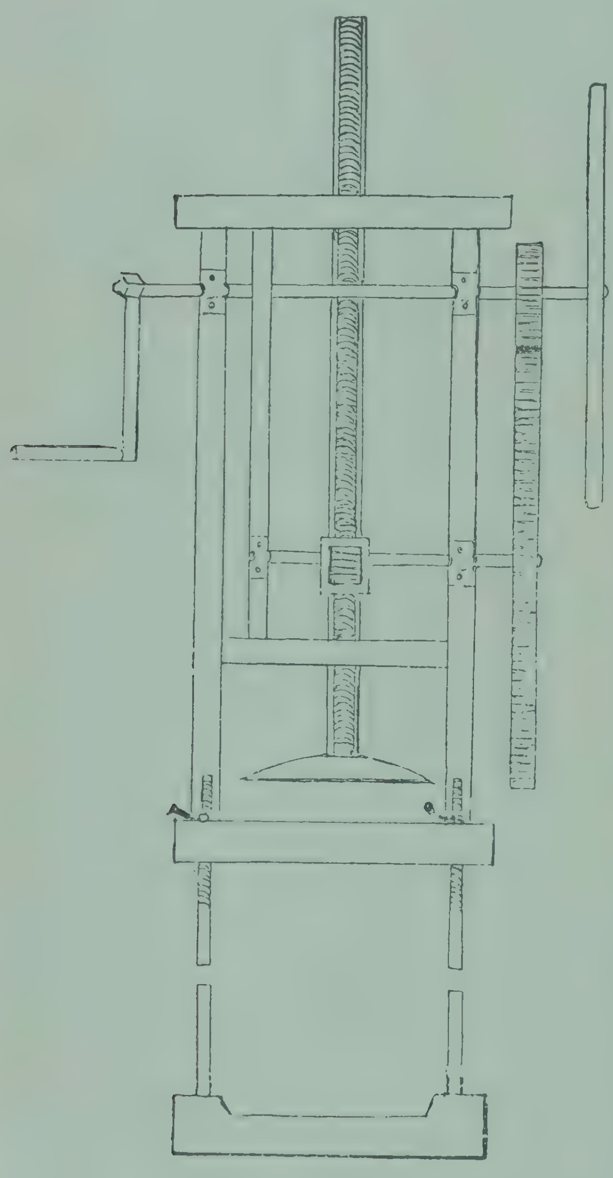


FIG. 6. HAND-POWER BALING PRESS.‡

A Sea Island bale of cotton, when ready for shipment, is a long cylindrical body with four ears (two at each end) and resembling a 'pocket' of hops. There are no bands or hoops. The stitching along the side and ends of the bag is strong enough to bear all the pressure considered

‡ A hand-power baling press exactly similar to the above is now in use at St. Vincent. It is intended for dealing with the best qualities of Sea Island cotton only.

desirable to apply to the best sorts of Sea Island cotton. Usually two men bale and sew up all the cotton ginned in a factory running six gins and baling from 3,500 ℔ to 4,000 ℔. of lint per day.

COST OF GINNING.

The cost of ginning cotton in the Sea Islands is usually from 3c. to 4c. per ℔. of lint, the ginners supplying all baling material free of cost. As already mentioned, if the seed-cotton is not already picked over, whipped and assorted before it is sent to be ginned, an extra charge at the rate of $3·00 for every 1,200 ℔. of seed-cotton is made by the ginner. This is a matter that deserves to be borne carefully in mind by cotton growers in the West Indies. If the seed-cotton is not properly prepared beforehand it will be impossible for the ginneries to clean and bale it properly at so low a cost as 3c. to 4c. per ℔. of lint. The usual loss in weight in dry cotton, due to dust and impurities removed during the process of ginning, is at the rate of 5 ℔. for every 100 ℔. of clean lint.

COTTON WORM.

In the Sea Islands, the cotton plant is very subject to the attacks of the 'cotton worm'; but it is so readily kept in check by the application of Paris green, that the planters there have ceased to fear its appearance, and consider that the cotton worm question is solved. Great care, however, is taken to treat the plants as soon as possible after the appearance of the insect, as it is found that if caterpillars are allowed to grow to any appreciable size, much more of the poison is required, and then it does not always have the desired effect. In the cotton districts, when the caterpillar is from $\frac{1}{8}$ to $\frac{1}{4}$ inch long, the plants are dusted with the poison, which is distributed undiluted.

It may be interesting to place on record the treatment of caterpillar during the early days of cotton planting immediately after the Civil War. The following extracts are taken from a review of the condition of the Sea Islands published in 1880:—

'This risk, [of caterpillar] however, has been greatly reduced under the new system of cultivation. Under-drainage prevents a loss of the crop from heavy rains, and the means used for destroying the cotton worm are looked upon as absolutely reliable. The caterpillar which a few years ago was regarded as a plague which could not be averted, no longer has any terrors for the planters. I consulted nearly every planter of prominence on the island, and there was not a single one who expressed the slightest concern whether the caterpillar came this year or not. The Paris green mixed with flour and rosin and spread over the plants is certain death to the worms before they can effect any damage. The cost of applying this preventive is about $3·00 an acre, and the appearance of the caterpillar is not considered as entailing any loss beyond the cost of preparing for their reception. The islands, it should be remembered, have not had a general visitation of caterpillars since 1867, and it may be possible that the means which have proved so successful in destroying small bodies of the worms may prove to be inadequate to stop the ravages of an army

of them as large as that which passed over the islands thirteeen years ago. It is to be hoped, however, that the sense of security now enjoyed by the planters may not be rudely destroyed by the fulfilment of any such prophecy.'

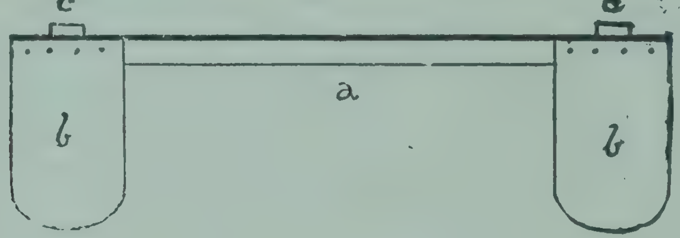
In reference to John's Island it is stated: 'The caterpillar has lost its terrors to the John's Island planters as well as to their neighbours. They use the same means for destroying them and look upon the preventive as absolutely sure.'

At James Island it is mentioned that 'The caterpillar is not given much thought. The Paris green and flour is used here as on the other islands, and is looked upon as a certain preventive. The mixture is made as follows: 50℔. of flour, 1 ℔. of Paris green and 3 ℔. of rosin. The cost of the material and the cost of spreading it is about $3·00 an acre. A new article called London purple is to be tried by some of the planters this season. It is said to be even better than the Paris green, and is cheaper.'

These extracts have an historical value only. They, however, very clearly prove that the caterpillar need not seriously damage the cotton plants except in cases where it is allowed to escape the vigilance of the planter and to increase to such an extent as to eat up everything in the field. The more modern methods of dealing with caterpillar are fully discussed in later portions of this report (pp. 326-34).

The method of application described by the Mississippi Experiment Station is the one usually adopted, and is as follows: 'Make two bags of heavy cloth, each about 10 inches long and 4 inches in diameter, open the whole length of one side and firmly sew at the ends. We have found 8 oz. osnaburg the best cloth for the purpose. Take a strip of oak or other strong wood, about 1½ inches by 2 inches and 5 feet long, and bore a 1-inch hole 5 inches from each end. Tack one of the sacks to each end of the pole, fastening one of the edges of the opening to each of the narrow sides of the pole.

'The sacks can be filled by pouring the poison through a funnel inserted in the holes through the pole and distributed by riding on horseback through the cotton rows, dusting two



SKETCH OF APPARATUS FOR DISTRIBUTING PARIS GREEN AND LIME FOR CATERPILLARS.

(a). bar of wood 5 feet long; (b) bags of osnaburg for holding powder; (c) openings in head of bar for inserting powder with stopper to prevent powder being spilled in handling. The bar may be provided with one or two bags as found convenient.

rows at a time. A little practice will enable one to do this work very evenly, and care must be taken not to allow the sacks to touch the leaves when wet or the poison will not pass

through. When the sacks are freshly filled, a very slight jarring will shake out a sufficient amount of the poison, but when nearly empty the pole should be frequently and sharply struck with a short stick, or spaces in the row will be missed.'

Full information in regard to the fungoid and insect diseases of cotton have already been published in the *West Indian Bulletin* (Vol. IV, pp. 255-86: see also pp. 326-48). Further notes on the subject will be published from time to time in the pages of the *Agricultural News*, the fortnightly review of the Department.

TREATMENT OF SEED.

In the Southern States when the seed is kept for replanting it is first of all sieved so as to separate any of the unginned cotton that may have passed through the grids. In the large factories, all the seed is sieved, and the small pieces of seed-cotton thus obtained are reginned. It is usual in these large factories to bale such cotton separately and not mix it with the better quality. In one large factory visited, the cotton is sieved a second time. Any seed not passing through, from its having a small quantity of lint attached, is recleaned in a saw gin. This lint is also baled separately.

In the smaller factories, the sieve used for cleaning cotton seed is made of a frame, 4 feet long by 2 feet wide, having a bottom of $\frac{1}{2}$-inch mesh galvanized iron wire netting. This sieve is run on two slips of wood fastened to the inner part of the longest sides of a frame which is supported on four legs. The motion is communicated to the sieve by means of a crank shaft to which a small fly-wheel and handle are attached.

COTTON SEED FOR PLANTING IN 1904.

The following information in regard to Sea Island cotton seed for planting in 1904 is taken from the *Agricultural News* (Vol. II, pp. 401-2):—

During the planting season of 1903, the demand for cotton seed was so unexpectedly large that it was almost impossible to deal with it. Fortunately, the British Cotton Growing Association was in a position to afford valuable assistance in the matter, and it is probable that nearly 1,000 bushels of cotton seed were presented by the association to various persons in the West Indies up to September last. In addition, seed was obtained by the Imperial Department of Agriculture from the Southern United States, from Egypt and Peru. In most cases the seed was distributed free of cost.

For the purpose of testing practically the capabilities of the various kinds of cotton under the conditions existing in the West Indies, a large variety of seed was tried. At present there is planted in these islands a considerable area in several sorts of Sea Island cotton, and there are smaller areas in Egyptain cotton, in the several sorts of Upland cotton, Peruvian cotton, and in a few local forms that have been found in a more or less wild condition at St. Lucia and Barbados, or under cultivation by small settlers at Carriacou.

It is too early yet to speak definitely as to the relative value of all these; but there can be no doubt, as already recommended by the Imperial Department of Agriculture, that the best all-round varieties for cultivation in the West Indies are the fine, long-staple sorts of Sea Island cotton. The plants themselves are hardy and easily cultivated and the return, in value, (though not always in weight of lint per acre) is larger than that from other cotton. It is stated that the best Sea Island cotton can only be grown successfully in districts more or less under the influence of sea-air. We may conclude, however, that there is no part of these islands, with moderately good soil, where Sea Island cotton of some sort cannot be grown.

Owing to the possibility of crossing with other varieties, the seed of Sea Island cotton obtainable this year in the West Indies cannot be depended upon. In fact, it would be unwise to use any local seed for establishing cultivation in 1904. In subsequent years local seed might be carefully selected and attempts made to raise strains specially suited to the West Indies.

Cotton is usually planted in the United States in April of each year. All the best seed for planting purposes is usually taken up before that time. With the view of securing, beforehand, a large supply of seed of the best Sea Island cotton for these colonies, the Imperial Commissioner of Agriculture, during his recent visit, obtained the refusal of all the seed produced on one of the most successful plantations on the seaboard of South Carolina. On this plantation the proprietor has for several years carried on experiments, in conjunction with the United States Department of Agriculture, in raising disease-resisting varieties as described in the *West Indian Bulletin* (Vol. IV, pp. 201-14). The lint is of fine quality and has uniformly obtained high prices. The seed will be carefully cleaned and assorted, and will be delivered with a guarantee that it is the produce of this plantation and no other.

It is estimated, as already announced in the *Agricultural News* (Vol. II, p. 379), 'that this seed will cost, delivered to the planters in the West Indies, about 7c. per ℔. (or at the rate of 1*s.* 9*d.* per acre), and as it will have to be paid for when ordered, those requiring it should note that it must be paid for in advance.' The date for closing orders for this seed has now been extended until the mail due at Barbados on January 4, 1904. After that date the Department will be unable to procure any further supplies of this selected Sea Island cotton seed. It will, however, continue to assist in obtaining other seed; but the latter may not be of so good a quality, and it may cost more. In the Sea Island cotton districts the cost of selected seed for sowing is placed at 54c. to 58c. (or at the rate of 2*s.* 3*d.* to 2*s.* 5*d.*) per acre. In Egypt it is placed at 50c. (2*s.* 1*d.*) per acre.

It would be convenient that all correspondence relative to the supply of the selected Sea Island cotton seed, above referred to, should be addressed to the local officers of the

Department, who will receive payments in advance, and give due acknowledgements for them. The seed will be deliverable in the West Indies about the end of January or the beginning of February. After its arrival it will be necessary to store it under suitable conditions until required for planting in June, July or August next.

The importance of selecting good cotton seed is very strenuously urged by Mr. Herbert J. Webber, Physiologist-in-charge of the plant-breeding laboratory connected with the United States Department of Agriculture :—

'As well might the breeder of fast trotting horses introduce dray animals into his stables, or the breeder of intelligent hunting dogs introduce ordinary mongrel curs into his kennels. The use of good seed and its production by a regular system of selection is just as important a factor in the production of the crops as that of cultivation. No intelligent method of farm management disregards the production and use of good seed. The day, when growers can afford to plant any sort of cotton seed, has passed. Only seed of a known variety selected because of its desirable qualities and adaptability to local conditions should be planted.'

YIELD AND COST OF PRODUCTION.

The yield of lint per acre varies considerably with the cultivation and manuring, but on fairly good soils the return is about one bale of 300 ℔. per acre. On one plantation on James Island, where the manure obtained from a number of cows (kept for supplying milk to the inhabitants of Charleston) was utilized, the yield on 69 acres last year was at the rate of 408 ℔. of lint per acre. This plantation was cultivated by the proprietor with labour at not less than 50c. per day. The yield of lint per acre on other plantations varied from 200 to 350 ℔. On small areas, owned or rented by white or negro settlers, the yield would sometimes not reach more than 150 ℔. per acre, probably due to want of cultivation and the continuous cropping of the land without the use of manures.

The cost of producing an acre of cotton in the Sea Island districts was a point on which it was difficult to obtain reliable information. Probably, the most reliable facts on record are those published in 1899 in Bulletin 156 (Division of Statistics) of the United States Department of Agriculture. The returns given in this are for the year 1896.

If we take the figures for Sea Island cotton grown in the county of Charleston, we find that the average yield per acre in four representative plantations, was 210 ℔. of lint and 117 bushels (714 ℔.) of seed. The lint was sold for 27·75c. per ℔., and the seed for 17c. per bushel. The total return for both lint and seed was $61·16. The total cost of production was $32·43, so that the net profit per acre on four Sea Island cotton estates in the county of Charleston in 1896 was $28·73 (£5 19*s.* 8*d.*).

If we now take the average returns on fourteen representative estates in the counties of Beaufort, Berkeley and Charleston

in South Carolina in 1896, the average yield in lint was 204 lb. and in seed 14·3 bushels (600 lb.). The lint sold for 26·15c. per lb. and the seed for 31·7c. per bushel. The total return for both lint and seed was $57·87. The total cost of production was $35·40, so that the net profit per acre on fourteen Sea Island cotton estates in South Carolina in 1896 was $22·47 (£4 13*s.* 7*d.*).

It would be interesting to give the average cost of production under separate heads. These are as follows :—

Rent	$2·89
Ploughing	2·50
Seeds	·56
Planting seeds	·47
Fertilizers	6·94
Distributing fertilizers	·31
Chopping and hoeing	4·33
Picking	7·79
Ginning and pressing	4·95
Bagging and ties	·60
Marketing	1·82
Repairing implements	55
Other expenses	1·69
Total cost	$35·40

Pounds of lint	204
Price per pound in cents	26·15
Bushels of seed	14·3
Price per bushel in cents	31·70
Total return	$57·87
Profit	$22·47

Number of farms reporting	14
Cost of picking per 100 lb.	$1·26
Cost of production per pound	·15

In Egypt, the cost of growing cotton, the yield, profit, etc., are as follows :—

Rent of land including taxes	$27·00
Irrigation	7·00
Preparation of land, seeding, manuring, etc.	5·50
Cost of seed	·50
Cultivation, including hoeing, thinning, etc	2·00
Picking	4·00
Total	$46·00

The return from lint, seed, etc., is $66, thus yielding a profit of $20 per acre.

It is stated that at present cotton is the most profitable crop in Egypt, especially since the decline in the price of sugar.

COTTON GINNERIES.

COTTON GINNERIES IN THE UNITED STATES.

Factories for ginning cotton in districts where Sea Island cotton is grown in the United States are of two descriptions. First, those containing about six gins situated on plantations with 80 to 100 acres in cotton. These gin the plantation cotton and that grown by the smaller plantations and peasants in the immediate neighbourhood. Secondly, factories containing from thirty to forty gins run in connexion with oil factories and manure works which gin cotton for a whole district; the cotton, in most instances, being brought to the factory in railway vans.

The factories of the first description, which usually contain three stories, are about 80 feet long and from 25 to 30 feet wide. At one end of the building in the lower story (or sometimes in a separate building) the engine and boiler are situated, and at the other end, there is a weigh-bridge for weighing the cotton as it is received. Directly over this weigh-bridge, there is a hoist for taking the cotton to the uppermost story or cotton loft. In this the cotton is temporarily stored and spread out to dry: it is then passed to the gins in the second story by means of shoots passing through the floor, directly over the gins. The labourers at work in the loft, filling the shoots, have also to pick out any motes or discoloured cotton that may have escaped the pickers and assorters. As soon as the gins are started, the feeders take the cotton from the shoots through a small hinged door which can easily be shut in case of fire. On the seed-cotton being fed to the gins, the lint is separated from the seed. The former passes over a leather roller and drops on to an endless conveyor. The latter falls through the grids on to an inclined plane, and passes through the floor to the lowest story. While the lint is on the conveyor, any motes or other impurities are watched for and picked out. From the conveyor the lint is taken to the baling-room. In some instances this is in a separate room, adjoining the main building. In others, the baling press is in the further corner of the gin room. In most factories the shafting and pulleys for driving the gins are directly over them. In others they are overhead at an angle of about 45 degrees. In the more modern factories they are in the room underneath with the belting passing through the floor.

In the lowest room also, the seed is stored (1) for replanting the next season's crop, (2) for feeding the animals, or (3) for making manure. The large factories are of various sizes, one containing thirty gins and turning out 6,000 bales of cotton per season would have three stories, and be about from 100 to 120 feet long, and 60 to 70 feet wide, and about from 27 to 30 feet high. As in the case of the smaller ginneries, the upper story or loft is used for storing or drying the cotton, the second story for the gins and baling presses and the lowest for the machinery and for a screw conveyor for removing the seed and finally delivering it to the oil factory.

The seed-cotton which is usually brought to the large factories loose in railway vans, is elevated to the loft by means of a large galvanized iron tube, from which the air is exhausted

by a revolving fan situated in the lowest story. In the loft the cotton is automatically dumped by means of trunks with light doors which open outwards.

From the dumping chamber in the loft the cotton is conveyed by wooden pushers, similar to those used on sugar plantations for gathering the megass, to the shoot. Just under each shoot, and over each gin, there is a wooden trough into which the cotton falls as the door of the shoot is opened. From the trough, boys of about fifteen to seventeen years old feed the cotton to the gin. After the cotton passes through the gins and the motes are picked out, it is then collected into large rectangular baskets running on a tram line and taken to the presses. The presses, which are two in number, each attended by two men, are operated by hydraulic machinery. The cost of one of these presses, complete with engine, is \$275·00.

After the seed is separated from the cotton, it falls into screw conveyors which take it to a revolving screen. In this screen, the thoroughly cleaned seed is separated from seed having cotton still adhering to it, which has dropped through the grids without passing through the gin. The cleaned seed is conveyed direct to the oil factory, while that insufficiently cleaned is reginned. This seed is again screened, the clean seed as before going to the oil factory and the seed to which any lint is still adhering is then passed through a saw gin, which removes any remaining fibre. The remaining seed, now free from any lint, falls into a conveyor with the other seed and is taken to the oil factory. The lint from both these two latter gins is baled separately, as it is very much inferior in quality to that cleaned first.

COTTON GINNERIES IN THE WEST INDIES.

It is very creditable that within the short period of eighteen months several well-equipped ginneries have already been successfully established in the West Indies.

The first ginnery was started under the auspices of the Imperial Department of Agriculture and the St. Lucia Agricultural Society at the Rivière Dorée Experiment Station at St. Lucia in 1901. This was placed under the charge of Mr. George Barnard, a responsible local planter, who has continued to take a great interest in cotton growing. The gin was a Dobson & Barlow single roller gin, the cost of which was provided by the St. Lucia Agricultural Society. A cotton press was added later by means of a grant from the Imperial Department of Agriculture. The gin was operated by a horse-power driving gear. Recently an aermotor has been erected by Mr. Barnard which is reported to be working satisfactorily. Two Macarthy gins, loaned by the British Cotton Growing Association, are in charge of Mr. H. D. Hunter, at the Dennery Sugar Factory on the windward side of St. Lucia. A hand-power gin, received from the British Cotton Growing Association, is for the present located at the Agricultural School at Union for the instruction of the pupils and use of the small settlers in the Gros Islet district.

The first ginnery operated by steam power in the West Indies was started at St. Kitt's on Canada estate (lately transferred to Spooner's), under the control of Messrs. Sendall & Wade and managed by Mr. A. O. Thurston. This consisted of two single action gins and a tramping press driven by a Tangye horizontal steam engine. The first shipment of cotton from this factory comprised 12,000 ℔. of lint. This obtained 13½*d.* per ℔. in the Liverpool market.

A ginnery, also belonging to Messrs. Sendall & Wade and operated by steam power, was started at Montserrat in the beginning of 1903. This, at present, consists of two gins and a screw press operated by an oil engine. Another ginnery, owned by Mrs. Howes, is in active working on the windward side of Montserrat. A third ginnery is in charge of Mr. Wilkins.

A Government ginnery, driven by steam power and containing one double action, single roller gin, was opened by Lady Morris at Barbados on July 31, 1903. This was re-opened, after considerable enlargement, by Sir Frederic Hodgson, K.C.M.G., on February 25, 1904. At present it consists of a 12 horse-power steam engine, six single action Macarthy gins (Platts) and a hand-power baling press. The cost of this factory is placed at about £900. Mr. J. J. Law was engineer in charge.

It may be added that Messrs. H. E. Thorne & Son, at Barbados, have a private ginnery in operation with two Asa Lees single action, single roller gins, and a screw baling press of their own construction. Both the gins and press are operated by steam power.

A Government ginnery, driven by an oil engine with three single action, single roller gins (one Platts and two Asa Lees) and a hand-power baling press, was opened at Antigua by Lady Edeline Strickland on December, 11, 1903. A hand-power gin provided by the Imperial Department of Agriculture has been in active use at Antigua for nearly two years.

What is likely to prove the largest and most effective ginnery in the West Indies is now in course of being erected at St. Vincent under the direction of the Imperial Department of Agriculture. Mr. J. J. Law is engineer in charge. The factory will be a three-storied building, 90 feet long, 27 feet wide, with a 12-foot verandah. There will be a lower or basement floor, a ginning floor and a cotton loft. The roof of the verandah opening out from the cotton loft will serve for drying the seed-cotton. The machinery will be operated by a Hornsby-Akroyd oil engine and consist of eight gins—2 Platts, 2 Dobson & Barlows, 4 Asa Lees. There are two baling presses; one is an exact counterpart of that used for packing Sea Island cotton in James Island, South Carolina. The latter was furnished by Messrs. Lebbey and Bailey, of Charleston, S. C. A hand-power gin is also available at St. Vincent.

Mr. E. Y. Connell, an enterprising engineer, is engaged in establishing a central ginnery at Nevis, where he will be prepared to deal with all the seed-cotton likely to be produced

in that island. The engine and a gin have been loaned by the local Government. Two more gins are shortly expected to complete the outfit for the current season. All the gins are a contribution from the British Cotton Growing Association.

Two hand-power cotton gins and a press are in course of being provided for use in the island of Anguilla. In the Virgin Islands a cotton gin and a press, contributed by the British Cotton Growing Association, are proposed to be operated by an aermotor similar to that in use at St. Lucia. A hand-power gin is provided for use, if necessary, in the out-islands of this group.

According to a Grenada newspaper 'cotton machinery is being erected by Mr. L. R. Mitchell on the northern side of the careenage, St. George.'

At Jamaica, a Macarthy single roller gin and baling press have been contributed by the British Cotton Growing Association for the use of growers in that island. They are proposed to be ready for use during the current year.

Hand-power gins and presses have lately been obtained for use in Trinidad and British Guiana. These are intended to be used during the crop season of 1904.

In regard to all these ginneries it is desirable to place on record an appreciation of the very active part taken in their establishment by the British Cotton Growing Association. The total value of the engines, gins and presses contributed by the Association cannot be far short of £700. It is understood that, unless otherwise agreed upon, the engines, gins and presses are to be regarded as on loan and to remain the property of the Association.

COST OF GINNERIES IN THE WEST INDIES.

It may be useful to append to this report an approximate estimate of the cost of erecting a first-class Central Cotton Factory for dealing with Sea Island cotton in the West Indies, based on actual experience in these colonies.

It is understood that everything is new, and that the usual prices are paid for building material, labour and machinery. Where suitable buildings are already available the cost might be reduced about one-half.

The style of the new factory would be a three-storied building as shown on page 306. This would contain a basement floor sunk 3 feet below the surface of the ground, a ginning floor and a cotton loft, all under one roof, and a 12-foot verandah on the windward side; also an engine house forming a separate building at one end. The main building would be 100 feet long, 27 feet wide and 26 feet to the eaves of the roof. A covered way would be desirable at the further end from the engine-house to admit carts bringing in the seed-cotton to the factory, and enabling it to be hoisted by a pulley into the cotton loft.

I. *Buildings:*		
Cost of building, framing, boarding, and roofing a three-storied wooden building 100 feet long, 27 feet wide, with a 12-foot verandah, labour and materials	£1,000	
Foundations, cement, brick and stone work, including engine room and a solid masonry wall for fixing gins, etc.	£150	£1,150
II. *Machinery:*		
$12\frac{1}{2}$ horse-power oil engine complete ...	£235	
Pulleys, shafting, brackets and belting complete	£150	
Eight (8) gins	£200	
Tramping press operated by steam power and fixing	£200	
Sundry materials and fixing gins ...	£250	
Carriers for cotton in loft and ginning room, small stores etc.	£150	£1,185
Contingencies		£100
		£2,435

The factory above indicated should be able (working for three to five months in the year) to deal with all the seed-cotton produced on 2,000 to 3,000 acres. A smaller factory to deal with the seed-cotton produced on 800 to 1,000 acres might be installed for one-half the above estimate, depending on the locality, cost of freight, labour, etc. With an oil engine only a small quantity of spring or rain-water is necessary, and the fuel would be either American or Russian kerosene oil as found convenient. It is desirable, in ordering an oil engine, to state exactly the quality and character of the oil proposed to be used with it.

RECENT SALES OF WEST INDIAN SEA ISLAND COTTON.

The following particulars of recent sales of West Indian Sea Island cotton are taken from the pages of the *Agricultural News*:—

(*a.*) Information has been received by the Imperial Commissioner of Agriculture from the British Cotton Growing Association with regard to the sale of cotton recently shipped from Barbados. Of the 18 bales shipped, 11 were sold at $12\frac{1}{2}$*d.* per ℔. and 7 at $13\frac{1}{2}$*d.* The cotton is reported as being 'good staple, clean, fairly well prepared, but rather deficient in strength.' (*A. N.*, Vol. III, p. 5.)

(*b.*) We extract the following information on the experimental cultivation of cotton at St. Kitt's from a paper by Mr. O. A. Thurston, published in the *West Indian Bulletin*, Vol. IV, pp. 227-8:—

'Advices received by last mail report the sale of the first shipment of 12,000 ℔. of lint at 1*s.* $1\frac{1}{2}$*d.* per ℔.' (*A. N.*, Vol. III, p. 5.)

(*c.*) The Hon. Francis Watts has forwarded the following report by a firm of Liverpool brokers, on a sample of cotton grown on Hothersale estate, Barbados, received from Mr. H. Crum Ewing:—

'We refer to ours of August 25, and have to inform you that we got an excellent report on your sample, which is considered a particularly nice style of cotton, apparently grown from Sea Island seed. The sample is long and silky, and at to-day's value would be worth 14*d.* per lb.

'With regard to your inquiry as to what the cotton would fetch when the market is in a normal state, the values would be ruled entirely by the supply and demand of Sea Island cotton, quite irrespective of prices for the ordinary American description, that is, middling American might drop $1\frac{1}{2}$*d.* to 2*d.* below present quotations without influencing values for Sea Island cotton in any way, which has a special and limited market of its own. The range of value in Sea Island descriptions is very great, from 13*d.* for medium fine to 21*d.* for extra fine—probably at any period of the last twelve months, cotton equal to your sample would have brought 13*d.* to 14*d.* per lb.

'The further inquiry by us:—"We think that the sample quality of cotton is being planted to a considerable extent in the West Indies, and we would like to know if the market could take it up at the price you indicate, if it came forward in large quantity"—brought the following interesting reply:—

'"We are in receipt of your letter of August 28, with inquiry as to the amount of cotton (equal to your sample) which this market could absorb, at the value put upon it by our brokers.

'"The opinion here seems to indicate that spinners will take up all they are *likely* to have offered; the experience being that so little of this quality can be grown satisfactorily over a series of years. We give you the figures for Sea Island descriptions for the last four years, that is total sales and prices (fine and extra fine) as follows:—

1900.	1901.	1902.	1903 (to date).
350 bs.	890 bs.	130 bs.	280 bs.
$13\frac{1}{2}$*d.* to 21*d.* per lb.	$13\frac{1}{2}$*d.* to 20*d.* per lb.	13*d.* to 20*d.* per lb.	13*d.* to 21*d.* per lb.

'"You will see that the quantity sold has not been large, and over the period named prices have kept remarkably steady.

'"This cotton is principally used for making a specially fine thread used in needle work and lace working. It is an expensive article, and it is doubtful to what extent the demand would expand, without some shrinkage in value, if the supply were to be increased to any very large quantity."' *A. N.*, Vol. II, p. 323.)

(*d.*) The following is taken from a letter, dated April 27, 1903, from the Secretary of the British Cotton Growing Association to the Commissioner of Agriculture for the West Indies:—

'You will be pleased to hear that we have had two small consignments of cotton, grown at Montserrat, both of which were

very satisfactory. The first was sold at 10*d.* and a part of the second at 11*d.*, and we hope to clear the remainder at the same price. My committee will be very pleased to receive consignments from other growers. There is no doubt that the class of cotton which can be grown in the West Indies will secure a good market here. Cotton should be consigned to Liverpool or Manchester by direct steamer, as this saves a considerable amount of carriage. The cost of transit from Southampton to Lancashire towns is 38*s.* 7*d.* per ton against 9*s.* 2*d.* from Liverpool. This is a serious item.' (*A. N.*, Vol. II, p. 178.)

The following extract is taken from the *Demerara Argosy*, January 9, 1904:—

'Mr. Boyle reviews at length the prospects of cotton growing in the various parts of the British Empire, remarking in respect of the West Indies that cotton is being grown at Barbados, St. Christopher, St. Lucia, Antigua, and the Bahamas During the summer a sample of Sea Island cotton was received at Liverpool from Barbados, and it was declared to be the best cotton ever seen in England. On August 26, 6¼ tons of Sea Island cotton from the West Indies were sold at Liverpool at 26c. per ℔. Other Sea Island cotton from the West Indies brought from 21 to 24c. and West Indian Uplands brought 14½c.'

COTTON OIL FACTORIES.

As the probable cost of erecting cotton oil factories in the West Indies is likely to be of interest, the following brief information is given in the report. Further details may be obtained on reference to *Cotton and Cotton Oil* by D. A. Tompkins:—

Cotton Oil Factories in the United States are of various sizes. The sizes from which the greatest profits are obtained, are said to have a capacity for extracting oil from 40 to 100 tons of seed in twenty-four hours.

A 100-ton mill is conducted for less per ton for labour and fixed charges, but it has to pay more for freight on oil, hulls and meal to the consuming market. A 40-ton mill will cost more to operate, but will save this extra cost in freight.

In all the factories, labour-saving devices are as far as possible used so as to minimize the cost of production. Where the oil factory is run in connexion with a large ginnery, the seed is taken to it by means of conveyors which are screws working in long troughs. When the seed is brought to the factories in railway vans, it is shovelled into conveyors which run along the side of the railway track. These conveyors take it to the seed house from which, by means of elevators and other conveyors, it is taken to the boll screen in the factory. It is screened for two purposes. First, to remove such substances as sand, bits of soil, etc., that are smaller than the seed, and secondly, such as boll-lobes and locks of cotton, that are larger than the seed. These objects are accomplished by means of revolving hexagonal frames covered with metal having ⅓ inch perforations and with wire net of ⅝ inch mesh. Sometimes the

first half of the frame is covered with the perforated metal and the second half with the wire net. In other instances, two separate screens are used. During the passage of the seed through the screen with the metal perforation, sand and fine particles of earth, etc., pass through the perforations and are separated from the seed. During the passage through the second, the seed that is sufficiently cleaned, falls through and passes to a blower which blows it into the conveyor, leaving any particles of iron behind. The insufficiently cleaned seed is again ginned, and afterwards returned to the blower. The lint from the insufficiently cleaned seed is called Grabot. From the screen, the seed passes to the linters, which are machines for removing the short fuzz which is left on Upland cotton by the gins. After the seed is thoroughly cleaned, it passes to the huller, which is a machine for cutting the seed in pieces so that the kernel may be separated from the hull.

From the huller the cut seed is taken to a screen smaller than that used for separating the sand and insufficiently cleaned seed. This has perforations of $\frac{7}{32}$ inch. The kernels, or meats as they are called, pass through the perforations while the hulls roll down the inside of the screen and pass out as tailings. This screen, however, rarely effects the entire separation, and as the products leave it, there are still some kernels in the hulls and some hulls on the kernels. Various supplementary machines are used to effect thorough separation, such as shaking screens, revolving beaters, and conveyors with perforated bottoms, etc. The usual practice, however, is to have a shaker beneath the screen, on which the meats fall as they come through. This shaker removes most of the remaining kernels from the hulls. The hulls, which come through the first screen, are carried to the place of storage in a conveyor having a perforated bottom, so that most of the kernels yet remaining are sifted through and are taken back by a small conveyor beneath the larger one. From the separating screens, the kernels are conveyed to the mill, which usually has from four to five rollers of about from 24 to 60 inches long according to the size and capacity of the factory. These rollers make about 180 revolutions per minute. From the rollers the thoroughly crushed kernels are taken to the heaters, where they are cooked. The objects of the cooking are to coagulate the albumen so that it will remain with the solid matter in the press; secondly, to render the oil more limpid so that it will readily leave the meats, and, thirdly, to evaporate most of the moisture. The time for cooking the meats is usually about twenty minutes. As soon as the meats have been cooked, they are then taken to a machine called a former and made into thin cakes. These cakes are then wrapped in cloth, removed on a thin sheet of iron, placed in the press and there subjected to a pressure of about 1,600 ℔. to the square inch, for from ten to twenty minutes.

The oil as it comes from the press is caught in a shallow trough and runs off into a tank situated beneath the floor. Sometimes there are two tanks, the first one having an outlet pipe near the top. This is done so that the particles of meat, that may have escaped from broken press cloths, settle, and

the clear oil passes off into the second. After the cakes are taken from the press, they are usually allowed to remain for about twenty-four hours to dry. They are then taken to the cake cracker which grinds them into bits about the size of a maize kernel. From the cracker, the partially ground cake is taken to the meal mill, where it is finely ground between iron plates revolving in opposite directions at a rate of about 150 revolutions per minute.

FEEDING COTTON SEED PRODUCTS TO FARM STOCK.

Practical experience has been supplemented by carefully conducted experiments, both in the United States and Europe, with cotton seed, cotton seed hulls and cotton seed meal as food for cattle, sheep, pigs, horses and mules, with the result of demonstrating their high feeding value for all kinds of farm stock, with the possible exception of calves and pigs, to which they have frequently proved fatal.

The high feeding value of whole cotton seed has long been recognized, having been fed raw, roasted, steamed, or boiled to live stock, especially to cattle. Almost from the beginning of cotton culture in this country, it has been used to some extent as a feeding stuff, but since the introduction of the cotton-oil industry the superior feeding quality of the by-product, cotton seed meal, has led to a very general displacement of whole seed by the meal in localities where the latter is easily and cheaply obtained.

The value of cotton seed meal for producing meat, milk, and butter is well established. It is one of the cheapest of the highly nitrogenous feeding stuffs, and is therefore one of the most economical for balancing rations deficient in protein, such as those in which corn is the principal grain. As the analyses show, it is very concentrated and should be fed in comparatively small quantities in connexion with a large proportion of coarse food, such as silage, corn straw, corn stover, cotton seed hulls, etc., or with good pasturage.

Although milch cows will do well for an indefinite period on cotton seed or cotton seed meal as the sole grain food, it is better to add a second, such as corn meal or wheat bran, to the ration. If fed to cows in large amounts without proper admixture of other feeding stuffs, it is likely to injure the quality of the butter as regards flavour and colour. It appears, however, to harden the butter and thus enable it to stand shipment better. It has also been found to facilitate very materially the rise of cream by gravity.

Referring to the analyses of cotton seed hulls and meal in the previous pages, we find that neither of them is adapted for use alone as food. The hulls contain a large excess of non-nitrogenous matter, and the meal a large excess of protein; each lacks what the other has in abundance. The meal is well adapted by its composition to be fed with the hulls, and the hulls find their proper supplement in the meal. This relation is so evident, that the fact that it was not pointed out much sooner is peculiar, although the uninviting character of the

hulls as food doubtless had the effect of diverting both scientific and practical investigations from them.

The practice of fattening steers on a diet made up exclusively of cotton seed hulls and meal commenced about 1883. The business has so grown that it is estimated that probably 400,000 cattle, besides large numbers of sheep, were fattened at and near the oil mills of the South in the season of 1893-4. It is also likely that 100,000 to 150,000 milch cows were fed on rations made up quite largely of cotton seed hulls and meal. The usual ration for fattening cattle is 3 or 4 ℔. of meal at first, which is gradually increased to 6, 8, and even 10 ℔. per head per day, and all the hulls they will eat. The proportions vary from 2 to 6 ℔. of hulls to 1 of meal, the most common ration at present probably being 4 of hulls to 1 of meal. The feeding is continued from 90 to 120 days. All the information at hand indicates that this practice is both economical and profitable. The diet, apparently, does not injure the health of the animals nor impair the healthfulness of the resulting products, beef, mutton, milk and butter.

The North Carolina Station gives the following rules for the use of cotton seed meal and cotton seed hulls under different conditions :—

(1) *For maintenance:* Where it is desirable to feed an animal just sufficient to maintain it without loss, the following directions may be followed :—Hulls from rather green seed may be fed alone, the particles of seed kernels remaining accidentally with the hulls being counted on for maintenance, or, perhaps, even for slow fattening. Dependence, of course, is placed on the amount of kernels left in the hulls. With well-cleaned hulls, however, some cotton seed meal must be used, depending somewhat on the animal fed. With a cow, weighing 950 ℔., 1 ℔. of meal to every 7 ℔. of hulls has been shown to maintain the weight and produce about 20 oz. of milk per day. Probably 8 or 10 ℔. of hulls to 1 ℔. of meal when fed in quantity (as much as can be eaten clean) will support life and maintain the weight of meat stock.

(2) *For slow fattening:* Rations ranging from 7 ℔. of hulls to 1 of meal down to 5 or 4 to 1 may be used, depending on the animals fed and skill of the feeder. Each animal should be provided with just what it can consume and no more. With thrifty stock 4 to 1 will produce very good growth, and in mature animals it may be counted on to fatten in from 80 to 100 days.

(3) *For quick fattening:* Rations for making good beef quickly may range from 4 to 1 down to 2 to 1, or even 1·5 to 1, as we have fed steers successfully on the latter ration. For feeding half-fat cattle, from thirty to forty to sixty days: these last rates are well calculated to increase the body weight. But is doubtless a good plan to heed the German standard and feed the wider ration at the last, in order that more of the digestible food may be fixed as muscular tissue.

(4) *For milk:* For the greatest flow of milk we consider it a doubtful practice to feed exclusively on hulls and meal.

though both may be prominent articles in the ration. If cotton seed meal is fed in quantities sufficient to support a cow giving a large flow of milk, it may occasion danger to her health, as it certainly does where fed to pigs and calves in like manner. When a cow has passed four or five months of gestation, and the flow of milk has greatly diminished, she may be put on a ration of hulls and meal, which may be varied from 4 to 1 to as much as 7 or 8 to 1 of hulls to meal until she has dried off. This will support the cow well. It would be well all this time, however, to be feeding once per day some hay, stover, straw, or let her graze part of each day.

For two or three weeks before calving the cow's ration should be changed by substituting a succulent diet or bran for the cotton seed meal. A week before calving, if not already affected by the succulent diet, the cow should be thoroughly purged with Glauber's or Epsom salts in 1-℔. dose. Care should be exercised to see that the bowels remain loose; if not, repeat the dose at intervals, as needed, until the cow has come to her full yield of milk after calving.

(5) *For other stock:* To other than ruminating animals, the use of either cotton seed hulls or meal is yet of doubtful expedience. Hulls are considered too bulky for horses, but cotton seed meal may often be fed in small quantities to good advantage with the usual wide rations. Its action, however, on the nervous system is yet untried, so far as we are informed and it would only be safe as a small part of a ration to be used, much as linseed meal or flaxseed is sometimes used. This meal in small quantities, is not so laxative as linseed meal.

EFFECT OF FEEDING COTTON SEED PRODUCTS ON THE HEALTH OF ANIMALS.

Injurious effects of cotton seed products on certain kinds of farm stock have frequently been observed, and their cause has been the subject of many careful investigations, but it still an open question whether the injurious principle is an original constituent of the cotton seed products or whether it is developed as the result of decomposition before feeding or of a change within the animal's body. The indications are, however, that the chief danger lies in the use of material (cotton seed whole, cotton seed crushed, cotton seed meal or cake) which has undergone fermentation. All experience goes to show that fresh cotton seed products, especially cotton seed meal, can be safely fed to beef cattle, milch-cows, and sheep, although on account of its extreme richness it should be used with care in connexion with less concentrated feeds. It may be used with safety in larger quantities in winter feeding than in summer feeding. There is no doubt that its use as a food for young animals, especially pigs and calves, is attended with great danger. Its effect on horses and mules has not yet been sufficiently studied to warrant conclusions, but a few instances are reported in which it has been fed regularly for long periods with good results.

FURTHER NOTES ON PESTS ATTACKING COTTON IN THE WEST INDIES.

Insect Pests.

Mr. H. A. Ballou, B. Sc., the Entomologist on the staff of the Imperial Department of Agriculture, has furnished the following paper on the insects attacking cotton in the West Indies to supplement the information already published in the *West Indian Bulletin* (Vol. IV, pp. 268-86). Since the publication of that paper, serious outbreaks of the cotton worm have been experienced in Barbados, St. Kitt's-Nevis, Antigua, Montserrat and St. Lucia; St. Vincent being the only cotton-growing island in the West Indies to escape.

The cotton leaf-blister mite [*Eriophyes* (Phytoptus) *gossypii*, Banks] has continued to spread and has increased in destructiveness in Montserrat.

It is especially worthy of note that of all the islands in which cotton culture has been recently taken up, St. Vincent is the only one that has not suffered from insect pests. The cotton plant louse (*Aphis gossypii*, Glov.) and the cotton stainer (*Dysdercus annuliger*, Uhler) are the only pests of cotton known in that island, and these have not been reported as causing any particular injury.

THE COTTON WORM.

Damage: The cotton worm has caused serious damage to cotton in most of the islands where cotton is being grown on a large scale, but this has been due more to the fact that the supplies of Paris green ran out than to the serious nature of the pest. It has been found that to be successful in combating this insect, it must be dealt with while it is still very young.

In every case where it was not seen until partly grown, serious injury resulted. The worst outbreak occurred at about the same time in all the islands. In Barbados, from the middle of September to the middle of November, the cotton worm was present in greater or less degree in most parts of the island. During October nearly every cotton field was attacked and many suffered heavily. At the beginning of October, there was no Paris green to be had in Barbados and hand-picking of the caterpillars and pupae was the only course open to planters; many employed large numbers of boys and girls for weeks and succeeded in greatly reducing the numbers, but frequently, entire fields were completely defoliated, and a few fields were cleared of cotton by the planters who believed that it would never recover from the severe check it had received. Certain fields, however, that were left to recover as best they could after being striped of their leaves, have since made good growth and seem likely to produce fair crops.

Cotton planters in St. Kitt's-Nevis, Antigua, Montserrat and St. Lucia have had very much the same experience with this pest as those in Barbados and at about the same time. Reports from officers of the Department in these islands to the Head Office and the accounts given in the local papers tell

exactly the same story, viz., lack of insecticides and the inefficiency of hand-picking as a remedy.

Number of broods: The great range of time over which cotton is planted in these islands, and the absence of a winter or other weather conditions that compel a hibernating season on the part of the cotton worm, have made it difficult to determine the exact number of broods in a season or year. So far as observations have been made, however, they indicate that from four to six weeks (rarely less than four and probably never more than six) is the length of time required for each brood.

In observing the experiment plots of cotton at the Botanic Station in Barbados, the writer decided that three more or less distinct broods occurred between the middle of August and the early part of November. After the first week in November, the cotton worm practically disappeared and most planters believed that the season was over, and that no more trouble would be experienced until the next season.

About the middle of January, however, another brood made its appearance on these plots. This would indicate at least four broods, and there may have been one in December so small in number as to escape notice.

Early in February another attack of worms was experienced. This may have been another brood, but was more probably from belated females of the January brood.

Remedies: Paris green has been recommended as the insecticide best combining the qualities of efficiency and cheapness, and at present there is a good supply of it in the hands of the various dealers in Barbados and in the other islands. Several estates have also imported largely for themselves.

Several articles were published in the *Agricultural News*, indicating the method of dealing with this pest, and some modification in the strength of mixture was suggested as the attack increased in severity.

In Antigua and Montserrat a mixture of Paris green and dry, air-slaked lime at the rate of 1 ℔. Paris green to 6 ℔. lime is believed to be the best, while in Barbados 1 ℔. to 10 ℔. of lime is used with good results. In Montserrat this mixture has been applied in the same way that the undiluted Paris green is applied in the cotton-growing States, viz., by means of a pole long enough to reach from row to row, with a bag of coarse cloth at each end. This is carried by a boy riding on a mule and the poison shaken out by jarring the pole with sharp blows of a short stout stick.

The mixture at the rate of 1 to 6 has given such good results where it has been tried, that it is now being quite generally used in Barbados, and is being recommended by the Imperial Department of Agriculture.

In Antigua the horse or mule is not used, but a bag of coarse cloth is fastened to the end of a pole, about 3 feet long, and the poison is shaken out by striking the pole with a stick carried for that purpose. In Barbados no pole has been used,

the bag being held in the hand and shaken over the plant. Those who have tried both the latter methods generally prefer the bag upon the 3-foot pole.

When the supply of Paris green in Barbados was exhausted Mr. E. E. Thorne, of Sandy Lane, tried spraying with arsenate of lead to control the cotton worm. This is an extremely useful insecticide, and no other trials of its use against this insect appear to have been made in the West Indies. The mixture was used at the rate of 1½ ℔. to 100 gallons of water, and Mr. Thorne reports entire success; he believes that this gave better results than the Paris green applied either as a spray or dusted in any strength he has yet tried. If a strong mixture of Paris green is sprayed on the plant, the leaf is burned; while arsenate of lead can be used in any strength without injury. The latter can, however, be used only as a spray, since it is sold as a wet, pasty material, which could not be dusted on, and hence could be used only by those who possess spraying outfits.

The two chief causes of serious injury by the cotton worm should easily be eliminated another year. They are lack of proper insecticides, and failure to detect the pest at the beginning of its work. Careful inspection is necessary to find the caterpillars while they are still very small, and an application of poison should be made at once. The caterpillars increase in size very rapidly, and a delay of one or two days sometimes makes all the difference between saving and losing all the foliage of the cotton. Although this does not always result in the death of the plants, it gives them a serious check, from which they scarcely ever fully recover, although they sometimes make a partial recovery and a fair crop is obtained.

Each estate should have on hand at the beginning of the season, that is, very soon after planting, a good supply of poison. If Paris green is to be used, there should be not less than 2 ℔. for each acre planted in cotton, while even this amount will not be sufficient unless the caterpillars are taken in hand at the earliest possible moment. Since the cotton industry has so greatly increased the demand for this poison, the dealers in each island will undoubtedly keep much larger amounts in stock and the price will be much less than formerly. In Barbados, the retail price has dropped from 50 c. to 30 c. per ℔., and from having only a few pounds in stock, the dealers now keep hundreds of pounds.

In the Sea Islands of the United States, Paris green is applied dry and undiluted. The apparatus used is a bag of coarse cloth on the end of a pole. The method of planting on banks makes the use of a pole necessary to reach the tops of the plants which are somewhat above the height of a man. The poison is dusted from the bag by merely shaking the pole, not by jarring with a stick. As soon as the least sign of the work of the cotton worm is seen, the Paris green is immediately applied. Many planters dust only the affected areas and their surroundings, while others dust the entire field in which the attack is noticed.

The lime has been recommended in mixture with Paris

green, in these islands, principally that the labourer might be able to see what he has done as he goes along, and the overseer could also see that the work has been done thoroughly, since Paris green by itself would not be seen on the leaves. Moreover, the lime serves to prevent undue waste. The labourers in the cotton fields in the United States are accustomed to cotton as a principal crop, and realize that their living depends on the success of the crop; but in the West Indies this is different. The labourers having been brought up in the cane fields are not able to take the interest in cotton that they should, and their work is not reliable unless some check is kept upon them, so that it can easily be seen whether they have done their work properly. When the labourers become interested in the success of the cotton crop, and realize its importance to them, as well as to the planter, then it will be possible to use Paris green as it is used in other places, and get the same efficiency in results.

The following notes on the cotton worm and means of controlling it have appeared in the *Agricultural News*: some of them have also been reprinted as circulars and distributed to planters:—

Cotton in this island is just now seriously attacked by a caterpillar which eats the leaf. The insect spins its cocoon upon the leaf, drawing up the edges of a portion of it so that the pupa, which is inside, is entirely concealed. Certain fields have spots nearly stripped by this caterpillar, which is a voracious eater. When fully grown it is nearly $1\frac{1}{2}$ inches long, greenish in colour, with a dark stripe along the middle of the back, which varies in different specimens from a very faint black line on either side of the middle to a broad purplish black band, bordered on either side with a narrow whitish line, with a fine white line in the middle. This is one of the 'loopers,' or 'measuring worms,' and can easily be distinguished by its peculiar method of walking.

The remedies for this pest are the use of poison and hand-picking.

In certain cotton-growing States dry, undiluted Paris green is used as the poison. This is applied by means of cloth bags, at the ends of a pole long enough to reach two rows at once. A boy rides on a horse or mule between the rows and, by jarring the pole, dusts the poison on to the plants. This method has been very successful and is in general use.

In Barbados good results have been obtained from the use of a mixture of Paris green with dry, air-slacked lime, applied by hand from a coarse cloth bag. London purple may be used in this mixture. At the present time the supply of London purple and Paris green in this island is exhausted, and for the next few weeks hand-picking of the worms and pupae will have to be practised. This is being done on several estates and it seems to be entirely practical. After a little experience the labourers will detect the presence of the caterpillars on the leaf and of the pupae rolled up in the leaf, and the work can be done rapidly. The insects, when caught, can be dropped into kerosene or lime water and thus killed.

On one estate the practice of killing worms and pupae on the leaves is being tried, and appears to give good results. This is done by squeezing them between the thumb and finger; in this way the insect is killed, and the leaf may be left on the plant. This method is much faster than the collecting, and does no damage to the leaf.

On most fields, at the present time, the majority of the caterpillars have reached maturity, and having spun their cocoons, are now in the pupal stage. As it will be only a few days before the moths begin to emerge, and as each female moth lays a large number of eggs, the advantage of taking some steps to destroy as many of the pupae as possible, while they can so easily be reached, will be apparent. (*A. N., Vol. II, p. 330.*)

The following note on this cotton pest and the method of combating it has been communicated by Mr. W. N. Sands, Curator of the Botanic Station at Antigua :—

'A serious attack of the cotton caterpillar (*Aletia argillacea*) has made its appearance in the cotton cultivations at Antigua. In one case a whole field of cotton has been stripped. The pest is being fought by dusting infected plants with Paris green mixed with finely powered lime, the mixture being applied by means of a small osnaburg bag fixed to the end of a short stick. This method so far appears to act more effectively than spraying. Already 100 ℔. of Paris green have been distributed, and dusting is being energetically carried on.'

This insect has also appeared in large numbers in Montserrat, St. Kitt's-Nevis and Barbados. A modification of the method of dealing with the pest adopted by Mr. Sands was recommended by the Department for trial in these islands and it has already given very good results in Barbados. (*A. N., Vol. II, p. 346.*)

In a previous number of the *Agricultural News* (Vol. II, p. 330), the use of Paris green as a dry mixture with finely-sifted, dry, air-slaked lime has been recommended. The dry mixture has been the more strongly advocated because it requires no expensive apparatus for its application and because there are so few spraying outfits in these islands. While the cotton worm occurred only sparingly, as was the case at the beginning of the season, 1 ℔. of Paris green in 50 to 100 ℔. of dry lime seemed to be sufficient; but now that every field attacked soon comes to have enormous numbers of caterpillars, this mixture is found to be too dilute.

Recent trials of a mixture at the rate of 1 to 10 seem to give good results; while the Hon. F. Watts and Mr. W. N. Sands write that in Antigua the mixture is most successfully used at the rate of 1 to 6.

The amount necessary per acre varies, of course, according to the size of the plants, but in Antigua 1 ℔. of Paris green has been found to serve for one application for ½ to 1 acre. An experiment, conducted at the Botanic Station, Barbados, has

indicated that, mixed in the proportion of 1 to 10, 1 lb. of Paris green will be sufficient to dust $\frac{1}{3}$ to $\frac{1}{2}$ acre.

Used as a spray, Paris green has been recommended in a mixture at the rate of 1 lb. to 150 gallons of water with two or three times its own weight of lime. This mixture may be made stronger—1 lb. to 100 gallons of water—if a proportionate increase in the amount of lime be made. In preparing a Paris green mixture for spraying, the poison should first be mixed with a small quantity of water and then added to the full amount, otherwise there is a possibility of its not getting thoroughly mixed. (*A. N., Vol. II, p. 362.*)

Mr. J. R. Bovell, F.L.S., F.C.S., who has just returned from a visit to the United States, informs us that the cotton growers there have little fear of the cotton worm. The use of Paris green is commenced as soon as the small caterpillars appear, and thus serious damage is prevented.

Dr. L. O. Howard in his *Insect Book*, mentions that in one year Mr. E. A. Schwarz, of the Division of Entomology of the United States Department of Agriculture, found, while studying the habits of the cotton worm, that about 75 per cent. of the worms were killed by parasites.

These facts may furnish encouragement to West Indian planters, for prompt action on their part, and the aid of the parasites, which will probably increase from year to year, should prevent any serious injury except in occasional severe years.

Extreme scarcity of any insect, which serves as host for a parasite, results in a season of scarcity of the parasite, which gives the host a chance to increase again. This increase in host is always followed by a corresponding increase in parasites, which finally become so numerous as nearly to exterminate the host.

Even in the United States, where the cotton worm and its parasites have been in constant inter-relation for many years, there are occasional seasons when the cotton worm is unusually abundant, and does considerable damage to the cotton crop. (*A. N., Vol. II, p. 378.*)

The St. Vincent *Sentry*, of October 23, has the following note with reference to specimens of the cotton worm, in all its stages, to be seen at the Agricultural School in that island:—

'In our last issue we reproduced from the *Agricultural News* an article giving the description of the pest which has attacked the cotton fields of Barbados, our object being to disseminate information which should, in the event of the cotton worm appearing in St. Vincent, prove advantageous to cultivators. We are pleased to learn that, with the same object in view, specimens of the cotton worm, its pupae and moths are now preserved at the Agricultural School here, and the Resident Master will be glad to show them to any one calling there on any day between 7 a.m. and 1 p.m. As a glance at the worm itself is much more valuable than reading the description, we advise those interested in cotton cultivation to see the specimens.

so as to be able at once to detect the presence of the pest, and thus be in a better position to cope with it.'

It may be mentioned that specimens of the cotton worm are also to be seen at the Planters' Hall, Bridgetown, Barbados.

COMBATING THE COTTON WORM BY MEANS OF PARASITES.

Among insects, as among all other groups of animals and plants. there is constantly going on a keen struggle for existence. Insects are preyed upon by other animals in other orders such as birds, toads and lizards, and by other insects, examples of which are very easy to find. The wild bees eat caterpillars; the dragon-flies or pond-flies capture and devour butterflies, grasshoppers and even other dragon-flies; lady-birds (coccinellids) eat plant lice and scale insects. Many more examples might be given. In addition to these predaceous insects, there are others still more common and much more effective in checking extreme outbreaks of insect pests. These are parasites, and they are extremely abundant.

Parasites are of two kinds—external and internal. Examples of the former are the very familiar reddish mites found attached to the body and wings of grasshoppers. These act in a similar way to those parasites of the higher animals, the lice and ticks of man, cattle, dogs, fowls, etc. In the insect realm internal parasites are of much more importance than external. These have a wide range in habit, structure, and relationship but the commonest are certain two-winged flies (*Diptera*) and certain of the wasp-like, four-winged flies (*Hymenoptera*). Insects of nearly all orders are attacked by internal parasites, and the attack usually results in the destruction of the individual attacked, or the host as it is called.

Two of these internal parasites have recently been reared from pupae of the cotton worm by the Entomologist on the staff of the Imperial Department of Agriculture. A large number of pupae were kept in boxes and jars under favourable conditions for the moth to emerge. After eight days no more moths emerged, but on the ninth and subsequent days a number of small flies appeared and a few small black and white *Hymenoptera*. Although at present nothing is known of the early stages of these insects, yet it is possible, from our knowledge of other similar insects, to give a general account of the life-history of each.

This parasitic fly is at first glance not unlike the common house fly, but comparison shows it to have more bright colours on the head, and the body is covered with rather long stiff hairs. It belongs to the family *Tachinidac* or 'Tachinid flies,' nearly all of which are parasitic.*

The adult female has no sting or ovipositor, so that when the eggs are laid they are merely fastened upon the skin of the

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* Since the publication of this article specimens of this parasite have been submitted to Dr. L. O. Howard, Entomologist, U.S. Deptartment of Agriculture, Washington, D.C., who gives its name as *Sarcophaga trivittata*.

caterpillar which is attacked. If the caterpillar sheds its skin at once, the egg may be cast off with it, but it generally happens that the egg hatches before the moulting of the skin takes place. In this case the small, white, footless maggot, which comes out of the egg, immediately bores its way through the skin of the caterpillar, which is now the host, furnishing both food and protection to the unwelcome guest. Here this small maggot lives and grows feeding on the vital fluids of the host. In spite of this tax upon it the caterpillar is able to go on to the pupa stage; but when this is reached and no more food is being taken in to supply the demands of the maggot, the guests eat up the host itself. All the concentrated energy and dormant life, which should go to develop a moth capable of reproducing its kind, are converted into a fly, whose object in life is to live at the expense of some other insect, and so instead of a moth there emerges from the cocoon a fly. The hymenopterous parasite differs from the fly in the method of depositing its eggs. This one has a sting-like ovipositor, by means of which it is able to insert its egg under the skin of the caterpillar, and then there is no escape for the unlucky host.

At present the cotton worm parasites are very few in proportion to the extreme abundance of the host, but later the proportion of parasite to host will be much higher.

Insects in their native localities and under normal conditions are less likely to become epidemic, than if they are introduced to new localities or if the conditions become considerably changed. This is because the relation of host to parasite is upset, the parasites having to accustom themselves to the new host, or the host having opportunities for rapid development which enable it to increase to a remarkable extent in spite of its parasites.

Extreme abundance of any insect pest is usually followed by a season of comparative scarcity, which is due to the developement and increase in number of the parasite consequent upon the extreme abundance of its host or food supply. (*A. N., Vol. II, p. 362.*)

LIFE-HISTORY OF THE COTTON WORM.

In addition, the following circular, giving the life-history of the moth, was printed and distributed to planters and others early in November 1903:—

The life of the cotton worm is divided into four distinct periods or stages, which always occur in the same order. There can be no change of sequence, and it is impossible for any stage to be left out. The four stages are the egg, the larva, the pupa and the adult.

While the egg of this insect is small and perhaps not commonly known, yet every one knows the nature and function of an egg, and in these respects the cotton worm egg is like all others. It is small, rounded, greenish in colour, and when seen with a lens shows fine radiating lines upon its upper surface.

The eggs are laid on the under surface of the cotton leaf and are scattered about, not in clusters.

The larva is more commonly called the caterpillar or worm. The last of these names is incorrect, because the caterpillar of a moth or butterfly is in no sense a worm. The name cotton worm has, however, become so well established that it seems advisable to retain it rather than to attempt to change it, thereby, perhaps, creating great confusion.

The skin of a caterpillar is not capable of much growth after it once becomes hardened. In order, therefore, to increase its size to the full, it is necessary for the animal to shed its skin several times, each new skin being much larger than the preceding. The new skin is already developed under the old one, and is very soft but soon becomes distended and firm. At the last of these 'moults' or changes of the skin, instead of another caterpillar skin, a dark-brown thick covering is developed, the body is much shortened and the pupa or chrysalis appears.

Some insects roll up leaves or spin silken cocoons, previous to the last moult, in which to pass the pupal period. The cotton worm generally ties over merely an edge of the leaf, though sometimes, if suitable cover is not at hand, the pupa is formed almost without cover.

In the pupa stage the wings, mouth-parts and antennae of the adult are developed, the reproductive organs being perfected from mere rudimentary forms. At this time the insect does not feed and has no power to move from place to place, its only power of motion being a wriggling or twisting movement, which is frequently noticed when the pupa is disturbed.

When the necessary changes have taken place within the dark-brown pupa skin, it breaks open and the adult insect crawls out. At first its wings are very small but they quickly spread out, and in a very short time the small, olive-grey moth is dry, its wings strong and it is able to fly. The caterpillar has strong biting jaws and it swallows its food in solid particles; but in the moth the mouth-parts are so changed that no jaws are to be seen, but instead a long slender thread-like proboscis, by means of which it sucks up the nectar from flowers.

In this stage the insect does no damage to the cotton plant, merely sucking up enough of the nectar from the flowers and the nectar glands of the leaf to keep itself alive while performing the reproductive functions of mating and laying eggs. These moths are called 'dusk-flyers,' because they fly only in late afternoon and early evening. Each female deposits 300 to 500 eggs, taking probably a week or ten days in which to do it.

THE COTTON STAINER.

This insect has not done any serious damage to the present crop, although in Montserrat and Antigua it has been rather plentiful. In Barbados it is practically unknown to the

planters, and in St. Vincent, though present to some extent, it is not reckoned a serious pest.

The cotton stainer multiplies rapidly and the young congregate in the opening bolls and suck the juice from the tender seeds. The adults have been seen on a large variety of plants, but, so far as the writer has been able to see, feed only upon cotton.

Traps of sugar-cane and cotton seed have been tried, and when the bugs have congregated upon them, they have been sprayed with kerosene, kerosene emulsion or drenched with hot water. When hot water is used, the efficiency of the traps is not destroyed; but when kerosene emulsion or pure kerosene is used, the insects would probably not congregate on the same trap again.

Mr. Sands writes from Antigua, and Mr. Knowles from St. Vincent, that cotton seed has proved more successful as a trap than pieces of cane.

When in Montserrat, the writer recommended several small proprietors to try the following for controlling the cotton stainer:—

Take a bucket or other vessel and put about 2 inches of water in it; pour just enough kerosene on the water to make a perceptible film over the surface. Take this into the field and with a short stick jar the young bugs into the oil and water. In this way, with a little trouble, the insect can be kept within bounds.

No information is at hand as to the success of these trials but there is reason to believe that the stainer will be quickly killed by this treatment.

THE RED MAGGOT.

This is the larva of a small fly, at present unknown, and it damages the cotton by feeding in the young growing portion (cambium) of the stem between the wood and bark. Large numbers of these are to be found in a single wound and sometimes several infested areas are found in a single stalk of cotton. Sometimes the injury is so severe as to cause the death of the plant, but in other cases it merely causes dry, depressed areas of the bark.

So far, this pest is known only in Barbados, where it was first noticed, in November 1903, in a field of ratoons at Bushy Park. From the ratoons it seemed to spread to the fields of young plant cotton across the railroad track. Since then, it has been discovered in several districts in the island, but generally so few plants are affected that but little damage will be done to the whole crop.

The ratoon plants first attacked by the red maggot were pulled up and destroyed early in December. In other fields and on other estates, however, it has only been necessary to pull out and destroy single plants here and there.

It seems that in many cases this insect takes advantage of wounds or breaks in the bark, the parent fly probably depositing

eggs in the tender tissue thus exposed, but in many cases there is no evidence of any such wound, and probably the eggs are laid on the bark and the young maggots are able to penetrate the bark to the cambium. As the cambium is eaten out, the bark is separated from the wood and becomes shrivelled and dry. When one has become familiar with the appearance of these affected places, they are quite easily seen, even before the injury has proceeded so far as to cause a drooping of the plant. This drooping seems to occur only when the dead areas of bark extend nearly or quite round the stem, and indicates that the plant is dying. Overseers should do all that is possible to prevent labourers in the field from injuring the plants in any way. Any wound made with the hoe or by twisting or pulling the plant so as to cause any break in the bark is liable to be the point of attack for the parent fly, and though it may not be necessary for the eggs to be laid in a wound, it certainly will make it much easier for them to get in, if the parent fly deposits the eggs in a wound of that kind.

The life-history of this insect is not at present known, and although repeated attempts have been made to discover the egg and pupa, and to rear the parent fly, they have not been successful.

The young maggots are very small, whitish, without feet, later becoming reddish, and attaining a length of 4 mm. (about $\frac{1}{6}$ inch).

Although the writer has examined many affected stems, he has not been able to find the pupa, and believes that the maggot goes into the ground to pupate.

No remedy or preventive has been tried, and probably taking out the affected plants as they appear, will serve to keep the pest in check sufficiently to allow of the production of good crops.

THE COTTON LEAF-BLISTER MITE.

(*Eriophyes gossypii*, Banks.)

An account of this pest, its occurrence, distribution and destructiveness, together with a description of its appearance, and the appearance of the diseased plants was given in the *West Indian Bulletin* (Vol. IV, pp. 282-6).

In Montserrat, the mite has appeared in every cotton district and very few fields are free from it. It has not done much damage, however, except at Dagenham estate, where it first appeared. Here it has destroyed a large part of the present crop, working, as it did in connexion with the cotton worm. The caterpillar completely stripped certain fields, leaving only those leaves which were badly infested and distorted by the mite. As fast as the new leaves put out they were infested by the mite, and in this way the plants had no chance of making any satisfactory recovery and many fields were unable to ripen the bolls already formed at the time of the caterpillar attack. Convincing proof that this is due to the mite is found in the fact that in many fields, not attacked by the mite, plants, which were entirely defoliated, recovered, and give promise of an excellent crop.

In St. Kitt's, the mite is known to be well established, but no details of its destructiveness are at hand.

In St. Lucia, Mr. George S. Hudson writes that it is known in all parts of the island where cotton is grown, but that it has not yet become a serious pest. Mr. Hudson adds that he has long known the peculiar appearance of the leaves due to the presence of the mite.

Remedies : In St. Kitt's and Montserrat a large amount of labour has been expended in hand-picking affected leaves, and in most places good results have been obtained.

When in Montserrat in September last, the writer outlined and started experiments with various insecticides including mixtures of lime and sulphur. Owing to unfavourable weather conditions, these experiments were discontinued before any results were obtained. Since then, Mr. A. J. Jordan, Agricultural Instructor, has carried on a series of experiments which indicate that lime and sulphur dusted on the plants is the best of all mixtures tried, and indicate further that by its persistent use, this very serious pest may be kept in check sufficiently to allow of the production of a very good crop.

Three series of experiments on the control of the leaf-blister mite are now being carried out by Mr. Jordan. These consist of a series of box experiments with sterilized soil and sterilized seed, in several combinations, with checks: a field experiment of $\frac{1}{2}$ acre, divided into sixteen plots, located at the edge of an infested field, on which trials will be made of sulphur and lime in comparison with other insecticides, with untreated plots as checks. It is hoped that these experiments will have progressed far enough before the next planting season to make possible definite recommendations as to means to be employed in field operations. In addition, experiments are being tried to prove whether the mite infesting the *Acacia* will attack the cotton. The present distribution of the disease on cotton in Montserrat makes it seem likely that this has happened, and that the *Acacia* is the source from which the mite has infested the cotton. If this should prove to be so, a campaign against the acacias growing near cotton fields will be necessary.

The following is a brief preliminary report dated January 16, on a visit made by the writer to Montserrat to investigate this disease, and is followed by a later and more detailed report on the same visit, dated February 2 :—

I arrived in Montserrat on the morning of January 1, and left on the morning of January 14. I visited all parts of the island where cotton is being grown, examining as many fields as possible in each district, and found that the 'leaf-blister mite' is very generally distributed ; every district being more or less infected, though certain fields are apparently free from it.

No serious damage had been done except at Dagenham, and on that estate a large proportion of the crop has been lost by the ravages of the pest.

It seems quite probable that this mite has been communicated to the cotton from the *Acacia* sp., locally known as *Acacia arabica*. Infestation experiments and comparison of

the mites of both plants by experts are necessary, however, to decide this point finally.

Remedies such as cultural methods and insecticides are still in the experimental stage, and it is hoped that some definite results will be available before another planting season. Experiments with lime and sulphur, in equal parts, dusted on the young plants indicate that a certain restraint can be effected by this means.

I have carefully discussed the matter of ratoons with Mr. Watson, Mr. Jordan, and others, and believe that every effort should be made to persuade all cotton growers to cut and carefully burn all cotton plants as soon as the present crop is harvested. I talked also with several proprietors and they all expressed themselves as willing to follow the advice of the officers of the Imperial Department of Agriculture and the example of the managers of the estates in the island.

There are several points in favour of entirely replanting fresh areas in 1904, which should be especially brought forward in any discussion on the matter of ratoons:—

(*a*) Some time will elapse between the end of the present crop and the next planting season. If all cultivated cotton be carefully destroyed as soon as the crop is harvested, the mite will be deprived of its lodgement in the fields and probably greatly reduced in numbers on the next crop. Ratoons are also breeding places for scale insects and other pests.

(*b*) Planting is not expensive, and good seed can be obtained at a very low cost.

(*c*) Mr. Watson is of opinion that the fibre produced by ratoons is less in quantity than, and of inferior quality to, that produced by plant cotton.

(*d*) All cotton seed used in planting the next crop should be treated with carbon bisulphide. This will prevent the introduction of new pests with imported seed, and destroy any which may be harbouring in the seed raised in the island.

In clearing the present cotton fields great care should be exercised to remove every plant and all pieces should be picked off the ground and burned. I noticed that labourers are often careless, and unless continually watched, will leave a great deal of infested material lying about. In the case of very extreme infection, the land might be scorched over by covering it with cane trash and burning. This would produce sufficient heat to destroy the weeds, and a very large proportion of the mites, but would probably not seriously affect the humus in the soil.

I have the honour to submit the following report on my visit to Montserrat, from January 1 to 13 inclusive, to investigate the attacks of the leaf-blister mite of the cotton (*Eriophyes gossypii*, Banks) in that island.

During my stay in Montserrat I visited cotton fields in all districts of the island with the view of obtaining any new facts as to the present distribution, the probable origin,

and the seriousness of the infestation in different localities. In addition, a considerable share of my time was spent at Dagenham estate and vicinity and at the Grove Experiment Station, studying the development of the disease since my previous visit and devising and arranging the details of systematic experiments for its control.

Distribution of Pest: Dagenham estate is on the leeward side of the island; here where the leaf-blister mite was first noticed, the damage from its ravages has been more serious by far than in any other part of the island. Mr. Watson, the Attorney, informed me that the yield of cotton from 130 acres will be no more, and probably considerably less, than that obtained from 30 acres the previous crop. In several fields the cotton was being up-rooted and burned. These fields, under normal conditions, should have gone on bearing for two months longer. At Dagenham there was a serious outbreak of the cotton worm in October and in several large fields all the leaves were eaten off except those which were attacked by the leaf-blister mite. These mite-infested leaves were so distorted and deformed that they were of no use to the plants, and the mites from them infested the new leaves as fast as they were produced, making it especially difficult for the plants to recover. On other estates, fields which were entirely defoliated by the caterpillars and which were not infested by the mite, made good recovery and at the time of my visit gave promise of fair crops. The fields, that were first attacked, suffered most or they were completely destroyed first.

On the windward side of the island the leaf-blister mite is to be found in nearly every field of cotton. At Trants, fields which were in bearing and were slightly infested at the time of my visit in September had in January just finished an excellent crop. I was informed that these fields would soon be cleared and the plants burned without any attempt to produce a ratoon crop. Certain fields at Bethel and White's are infested but only in spots, and these spots for the most part are on the windward side of each field.

In the northern part of the island several fields of cotton belonging to the Montserrat Lime Juice Company were visited. These were slightly infested in each case and, as in other cases, nearly always at the windward side of the field. In the south part of the island the same condition was found, the infestation was slight and on the windward side of each field, showing that the pest had been carried by the wind and indicating that the mite in each case comes from outside the cotton field.

Leaf-blister mite of Acacia arabica: One of the most common of the Montserrat wild plants is the shrub known as *Acacia arabica*. This name is the one used in my previous report (*Agricultural News*, Vol. II, p. 309) and in the paper on the leaf-blister mite in the *West Indian Bulletin*, Vol. IV, p. 282, but since discussing the matter with the Curator of the Botanic Station at Dominica and seeing the plants there which are authentically named *A. arabica*, I believe

that this must be another species. It is extremely common and generally distributed over the island.

This plant is very seriously infested by an eriophyoid (phytopoid) mite, which causes small, sub-globular galls on the leaflets and peculiar, irregularly shaped blisters on the young tender wood of branches and newly formed spines. The mite is very similar to the mite of the cotton, but a little smaller (see *West Indian Bulletin*, Vol. IV, p. 282). The galls on the leaflets are not at all like those of the cotton leaf, but where the wood is attacked, very much the same effect is produced, as that noticed on the tender stems of cotton. It frequently happens that several galls occur upon a single leaflet and sometimes on both upper and under surfaces.

The galls are generally distinct and do not run together to form irregular, distorted masses, except upon the stems and spines where they frequently occur.

At Dagenham, there are no acacias growing very near the cotton fields, in which the *Eriophyes* was first discovered, but in every case of recent infestation as noticed at this visit, infested acacias occurred in greater or less numbers to the windward and generally at a very short distance. In spite of these facts, it is not possible to say definitely that this mite has come from the *Acacia* to infest the cotton. To prove this the following steps have been taken :—

(*a*) I have asked Mr. Jordan to try a series of experiments in communicating the disease from the *Acacia* to the cotton.

(*b*) The Curators of Botanic Stations, in those islands where the leaf-blister mite is known to attack the cotton, have been asked to submit to the Head Office specimens of any *Acacia* growing wild in the several islands, and especially any with distortions or deformities of the leaves.

(*c*) Specimens of affected leaves and twigs of both plants have been submitted to specialists for their opinions as to the identity of the species, based on structural details.

The fact that the cotton and the *Acacia* are rather widely separated, botanically, makes it necessary to look for much more detailed proof than would seem necessary, if they were more closely related. Any particular pest generally confines itself to a single species of plant, or at most feeds upon or attacks a few closely related species, rarely being found upon plants of different families. It is very extraordinary that the wild cotton is not attacked by the leaf-blister mite. Even when it grows so close to the cultivated cotton that the leaves of the two plants are in actual contact, the wild cotton never shows any sign of infestation, although the cultivated plants are most seriously infested.

Remedies : The remedies for the cotton leaf-blister mite are still in the experimental stage. The experiments which were commenced at the time of my visit to Montserrat in September were discontinued on account of unfavourable weather conditions. Mr. Jordan, however, carried out some experiments along similar lines, and his results indicate that a mixture of lime

and sulphur, in equal parts, dusted on the plants will help to control the pest. During this recent visit to Montserrat, I arranged for two series of experiments which should give more conclusive evidence as to the value of different insecticides in controlling this pest. One of these is a field experiment, for which Mr. C. Watson kindly provided ½ acre of land, which he had put in good condition for planting, and he promised the necessary labour for planting and for the application of the insecticides. The other series consists of several box experiments at the Grove Experiment Station. Mr. Jordan has undertaken the supervision of these, as well as of the infestation experiment already mentioned. It is hoped that these experiments will give results sufficiently definite to be of service in the preparation for the next crop of cotton. A report giving details of the experiments, the observations, results and conclusions, will probably follow in due course.

Nothing has been added to the knowledge of the life-history of *Eriophyes gossypii* during this visit. The working out of this life-history would require several weeks of continuous investigation, and knowing that the necessary time was not available for this purpose, I devoted myself to the investigation as given in the preceding paragraphs.

Summary: The following is a brief summary of this report with some conclusions that may be of more or less interest:—

(*a*) The cotton leaf-blister mite has increased in severity in those fields where it was already established, and has appeared in the cotton fields in all parts of the island.

(*b*) The attack of the cotton worm greatly added to the injury by the mite in badly infested fields.

(*c*) The appearance of the mite in recently infested fields indicates that it may have come from the common wild *Acacia*.

(*d*) Weather conditions, during the past season, have been rather unfavourable to the cotton, and consequently it suffered more from the attacks of the pests.

(*e*) Considerable time is required after infestation before the attack becomes a menace to the crop. Ordinary conditions of clean culture and the careful destruction of all plants growing in cotton fields, at the end of the crop season, will probably keep the pest within reasonable bounds.

(*f*) Experiments now in process should demonstrate remedial measures of value in the cultivation of succeeding crops.

General recommendations as to destruction of old cotton plants, ratoons and replanting, fumigating seed and burning over badly infested fields were given in a brief preliminary report, dated January 16.

Thanks are due to all who assisted in this investigation. Credit is especially due to Mr. Jordan who readily assumed the supervision of the experiments, and to Mr. C. Watson, who has provided land, labour, and insecticides for the field experiments, and lost no opportunity to assist me in my work.

The following notes were published in the *Agricultural News* giving information relating to the cotton leaf-blister mite :—

The following information respecting a disease affecting cotton at Montserrat is taken from a report presented by Mr. Henry A. Ballou, B.Sc., Entomolgist on the staff of the Imperial Department of Agriculture. Mr. Ballou visited Montserrat for the purpose of investigating the disease and advising in respect of the efforts to deal effectively with it.

Mr. Ballou's report, which is addressed to the Imperial Commissioner of Agriculture, is as follows :—

I have the honour to submit, herewith, a brief report on a visit, made at your request, to Montserrat from September 2 to 10, to investigate the disease of cotton caused by a leaf-gall mite, *Phytoptus* sp. This disease was first reported to the Department in July last, and specimens were sent in at that time.

Arriving at Montserrat early on the morning of September 2, I called on his Honour the Commissioner, and with the assistance of Mr. C. Watson began investigations, the results of which are briefly stated below.

Origin : The origin of the pest in this island is, at present, unknown.

Food plants : Careful search has failed to reveal any food plants of this mite, besides the cultivated cotton.

History : During July last, this disease developed to such an extent at Dagenham estate, near Plymouth, as to destroy several fields of ratoon cotton. Specimens were submitted to this office, and Mr. Watson stated in a letter accompanying the specimens that he was pulling up ratoons and destroying them. Since that time other fields of ratoons have been destroyed, until at present 37 acres of ratoons and 8 acres of young plant cotton have been destroyed on account of this mite. These were all at Dagenham. Several acres of ratoons have been pulled up at the windward for the same reason. At the present time the area planted in cotton in Montserrat is said to be about 700 acres. Most of this is growing in infested localities, and, probably, much the larger part in fields, some portions of which are already attacked.

Occurrence and spread : In each infested locality the disease made its first appearance in fields of ratoon cotton, and in every instance its spread has been in the direction of the prevailing winds, the spread in any other direction being very slight and slow.

Cause of the disease : The cause of the disease is a small mite, more closely related to the cattle ticks, red spiders, itch mites, etc., than to true insects. It is invisible to the naked eye, and even with the best pocket lenses can be seen only with difficulty.

Appearance of the disease : The disease appears most commonly on the leaves, causing them to become so crumpled and deformed as almost to lose their resemblance to cotton

leaves. The irritation induced by the presence of the mite causes the plant to send out adventitious epidermal hairs in great numbers. Subsequent growth produces a gall almost or quite closed, in which the animal feeds and lays its eggs. These galls are at first nearly of the colour of the leaf or stem on which they occur, but later take on a bright reddish colour and still later turn a dull brown and become dry and corky. At this time these galls open, and the adult mites, coming to the surface of the leaf, may be blown about. The galls occur on all parts of the plant except the root, having been found on leaf, stem, leaf-stalk, flower, pod and the bracts surrounding the pod.

Previous occurrence: So far as I have been able to determine, this is the first time that this disease has ever appeared on the cotton, and therefore, all remedies, for the present at least, must be applied experimentally.

Remedies: It is strongly recommended that all ratoon cotton be destroyed without delay, and that no ratoons be grown in the island for at least several years. Dry lime, dry sulphur, kerosene emulsion and whale-oil soap solution have been tried on a small scale, but sufficient time has not yet elapsed to make possible any estimate of the relative values of these substances.

Mr. Watson has begun the application of a lime wash on a large scale, and will try sulphur, both as a wash by itself and in combination with the lime. It is believed that the most efficient material must be one that will act as a deterrent, since the mite, once established, is so well protected by the gall it inhabits, as to be entirely out of the reach of the ordinary contact poisons. Lime and sulphur may therefore be expected to give the best results.

Conclusion and comment: In conclusion, I would state that it seems to me that this is by far the most serious pest of cotton, that I have yet observed, and that unless means of control are found, it will become more serious in the future than it is at present. Much remains to be learned of its life-history, means of control, etc.

I desire to express my thanks to his Honour F. H. Watkins, the Commissioner of Montserrat, for the kind interest which he took in my work, and to Mr. C. Watson, who did his utmost to help in every possible way, providing materials and labourers for experiments, as well as accompanying me to cotton plantations, and to the surrounding hills and wild lands, and supplying all information as to the occurrence and development of the disease previous to my visit.

On my return to Barbados, I found that the Sea Island cotton at the Agricultural School at St. Lucia was more or less infested with the same disease. The disease has since been reported from St. Kitt's. (*A. N., Vol. II, p. 309.*)

The Hon. Francis Watts writes suggesting that the following method of dealing with early attacks of the leaf blister-mite (*Eriophyes gossypii*) based chiefly upon suggestions made

by Mr. Lunt, Curator of the Botanic Station, St. Kitt's-Nevis, might be recommended :—

'The weeders, or others working in fields of cotton, should carry with them bags of close material, such as linen drill, and be instructed to pick and carefully place in the bag any leaves or other material seen to be infested with leaf gall. The bags should be carried out of the field with care to avoid spreading the infection, and on arriving at a convenient spot should be plunged into boiling water, and left there for an hour before their contents are removed.' (*A. N., Vol. II, p. 378.*)

FUNGOID PESTS.

Mr. L. Lewton-Brain, B.A., F.L.S., Mycologist on the staff of the Imperial Department of Agriculture, has contributed the following paper in continuation of that published in this volume of the *West Indian Bulletin* (pp. 255-68) on the fungoid diseases which have appeared on cotton in the West Indies during the past planting season. This latter paper applies chiefly to Barbados, where the cotton has been kept constantly under observation. Specimens have been received and examined, however, from some of the other islands, especially Montserrat and St. Vincent, which indicate that the diseases appearing there are in the main the same as those found in Barbados.

In considering the fungoid diseases that have appeared on cotton during the past season, there are one or two points which must be borne in mind, before any conclusions are drawn with respect to the prospects of the cotton crop and its diseases in future seasons.

In the first place cotton, in these islands, is a new crop. Many planters tried cotton last season, for the first time, without certain knowledge as to the proper methods of cultivation. The best time for planting was not known ; we were ignorant as to which soils and situations were most suitable for cotton, and there was no practical knowledge of the right distances for the plants or of many details of the cultivation.

Again, the climatic conditions during the past season have been very exceptional. November, which is usually a wet month, was very dry ; consequently the growth of the cotton was checked. December and January, on the other hand, which are usually dry months, have been extremely wet ; so that the maturing and ripening of the bolls have been brought about under moist conditions. Probably, if these last two months had been more normal as regards rainfall, fungoid diseases would have been far less abundant.

Then, in October and November, the cotton was badly attacked by the cotton worm. On many estates the plants were practically stripped of their foliage and the crop received a severe set-back. This attack, of course, seriously lessened the strength and vigour of the cotton plants, and consequently they succumbed far more readily to the attack of fungi than would otherwise have been the case.

LEAF DISEASES.

Leaf diseases have been fairly abundant. Among those that have been noticed are the 'angular spot,' due to a bacterium (*Pseudomonas malvacearum*); 'leaf blight,' due to a fungus (*Sphaerella gossypina*): and cotton 'rust,' due also to a fungus (*Uredo gossypii*).

Angular Spot: This disease, as its name implies, makes its appearance as small angular spots on the leaves, which are usually bounded by the small veins. The spots at first have a watery appearance, but later turn black and light brown; very frequently, and this is quite characteristic of this disease, the spots follow the main veins of the leaf, forming dark lines running alongside the veins, an inch or more long and $\frac{1}{8}$ to $\frac{1}{4}$ inch broad.

Leaf Blight: In this disease we find roundish but somewhat irregular spots on the leaves. These spots are characterized by the possession of a brownish-white centre surrounded by a dark red-brown or brown margin. The fungus has two stages in its life-history; in the first, or *Cercospora* stage, it reproduces by means of long, curved, multicellular spores (conidia); in the second, the *Sphaerella* stage, perithecia containing asci with ascospores are formed.

Cotton Rust: The rust forms small, brown, angular or roundish spots on the upper side of the leaves. The spores (uredospores) are formed in clusters on the lower side of the leaf; they break through the lower epidermis forming small, brown pustules.

Other Diseases: The red colour so common in cotton fields towards the end of the season is in part due to these fungi, in part to others which have not yet been identified with certainty, and in part to a natural process of ripening. Sometimes this red colour appears in younger leaves, without any fungus attack, and may then be taken as a sign that the soil, situation or climatic conditions are unfavourable to the growth of cotton.

Importance of Leaf Diseases: Leaf diseases of cotton cannot be described as being of serious importance in the West Indies. The only one of these noticed which has ever been reported as causing serious damage is the rust, and this, in the West Indies, like all the others, appears to attack only old or unhealthy leaves. The young foliage, except when the plants have been weakened by insect attack or unfavourable soil conditions, seems always to be healthy. It is not to be expected, when the plants are getting old and maturing their fruit, that they will show the same bright green crown of foliage that they do when young and growing vigorously.

DISEASES OF THE BOLL.

A few diseases of the boll have appeared on cotton during the past season; the most important of these are a boll rot, due to a bacterium, and a disease which is very similar to that known in the United States as 'anthracnose' and due to the

attack of a fungus, *Colletotrichum gossypii*; this latter disease may, for the present at least, be called 'anthracnose'. Neither of these diseases, however, has been very abundant.

Blotches on the Bolls: It has been of frequent occurrence, however, to find the cotton bolls marked with red or dark-coloured blotches, and these may be due to fungoid attack. The blotches are large and irregular, frequently covering one-half or more of the fruit. The spots are not sunk or depressed, in fact, they are not marked in any way, except by their colour. It has been suggested that the blotches are due to the attacks of the fungus *Sphaerella* (Cercospora) *gossypina*, which, as has already been mentioned, forms spots on the leaves of cotton, and which also attacks the involucre of the bracts around the base of the boll. This fungus is credited in the United States, with forming irregular blotches on the fruits. The dark-coloured blotches give the bolls an unsightly appearance, and, at first sight, an attacked boll looks badly diseased. More careful examination, however, shows that the injury is purely superficial, and it is noticed that the boll will ripen and open quite naturally, the cotton and the seeds being quite uninjured. This view of the non-importance of the *Cercospora* blotches, also obtains in the United States.

Dropping of Bolls: The dropping of the bolls has also been noticed on a few occasions. This phenomenon is not due to any fungoid or bacterial attack, but simply to external causes. It usually follows a sudden change of climatic or other conditions, which disturbs the nutrition of the plant, such as heavy falls of rain following dry weather, or *vice versâ*. It was noticed also in several localities following the attacks of the cotton worm. The plants, in this case, had to use all their reserves of food in the formation of fresh foliage, etc., and were in consequence, unable to mature all the bolls which had begun to form, the excess were therefore shed.

Boll Rot: This disease, which is due to a bacterium, is far more serious than those mentioned, though, up to the present, only one or two cases of it have been noticed in the West Indies. The rot starts in the inner tissues of the boll, near the point of attachment of this to the stalk. All the tissues at this point, including the cotton and the young seeds, begin to decay, and are transformed into a slimy mass. The decay gradually spreads through these tissues and finally involves the whole of the inside of the boll. It is not till this happens that one notices the disease from the outside, as the rot now begins to spread to the walls of the fruit, and these begin to present an unhealthy appearance.

The amount of harm done depends upon when the boll becomes infected ; if infection takes place while the boll is still young, the rot spreads through and affects the whole of the mass of cotton and seed inside the fruit; if infection takes place later, the decay will only affect part of the contents, and the plant will be able to mature the remainder and the boll will open.

Very little can be done, in the way of treatment, for the boll rot. The bacteria are, from the beginning, inside the

tissues and cannot be reached by spraying. The greatest care must be taken to destroy all diseased bolls as soon as possible. The fields should be watched carefully and as soon as the disease is noticed, all diseased bolls should be removed and destroyed at once; should this not be possible, the destruction must be carried out as soon as the picking is finished; on no account should the diseased bolls be allowed to remain on the field and decay there. It will be as well, in view of the possibility that the disease may be conveyed by bacteria remaining attached to the seeds, to avoid planting seed which has run a chance of becoming infected, either by coming from an infected field, or from a gin where diseased cotton has been dealt with.

Anthracnose: The anthracnose is the disease which is causing most anxiety in the West Indies. The disease appears on the fruit first as small red spots; later on, these enlarge and become black in the centre, the margin of the spot remaining red. The central part, owing to the action of the fungus in stopping the growth of the tissues, becomes depressed, and we now get a sunken black spot surrounded by a red margin. These spots are roundish and, at first at least, are fairly regular. The diseased area gradually extends until quite a considerable part of the boll is affected. Growth in the diseased area is prevented, consequently the boll becomes deformed and misshapen.

Reproduction of the Fungus: The fungus reproduces by means of spores which are produced in the centre of the diseased spots. A large number of small tufts of hyphae are put out into the air, close together, forming a spore bed; from the tips of these hyphae, small one-celled spores (conidia) are cut off. The spores are oblong-oval in shape, and measure $\frac{8}{1000}$ to $\frac{10}{1000}$ mm. by $\frac{3}{1000}$ to $\frac{4}{1000}$ mm. In the mass the spores have a pink colour. The spots now show a pink depressed centre, surrounded by a black ring, which is, in turn, surrounded by the red margin.

There is another fungus, commonly occurring on dead and dying bolls, which must not be mistaken for this one. It also produces pink-coloured spores, but these are long, sickle-shaped and multicellular. This fungus is a species of *Fusarium*, and it is, so far as is known, saprophytic, not parasitic, in habit, living on dead tissues.

Sometimes the boll is attacked while very young and then its growth is stunted entirely and the whole fruit dries up. The tissues inside such a boll become black owing to the hyphae of this fungus, and possibly also those of other saprophytic fungi. This stunting of growth of the bolls may follow from purely physiological causes, such as lack of nourishment, and must not be taken as a sure sign of anthracnose. In either case the seeds and cotton are, of course, useless.

No other spores have as yet been discovered, on diseased bolls, belonging to the fungus; and these small pink conidia do not appear to be very long-lived.

Cultures of the Fungus: The fungus can be grown from these spores on sugar-cane extract, made up with gelatine,

and on gelatine with an infusion of cotton leaves and twigs. In these cultures, the hyphae grow vigorously and in a few days, the mycelium again begins to produce spores. These spores are the same as those found on the diseased bolls; and in a few days the whole surface of the plate culture is pink with the numbers of spores produced. Up to the present, the mycelium has never, in these cultures, produced any other kind of spore.

The fungus is therefore capable of living as a saprophyte and of producing spores while so living; these spores are, of course, capable of infecting fresh cotton bolls. This shows the necessity for the thorough destruction of diseased material, and the necessity of not allowing other dead material on which the fungus can grow, to decay on the field. Any boll on which the fungus is growing will serve as a centre from which the spores may be distributed to unaffected bolls and plants by the agency either of wind or insects. It is possible that the latter may be attracted by the bright colour of the spores.

It is difficult to say exactly how much damage this disease has caused during the past season. In Barbados, at least, only a very small percentage of the bolls appears to be attacked, and in a more favourable season, probably, this will be even smaller.

Prevention of Anthracnose: For preventive measures, the one that is at present most necessary is the careful destruction, either by burning or burying, of all diseased material. Probably it will be better to bury in a cane field all plant remains after the crop has been gathered.

Should the disease become more abundant in future seasons, it will probably be found possible to raise resistant strains of cotton by selecting seeds from plants on which none of the bolls are attacked. Care will of course have to be taken that the quality of the cotton produced does not, at the same time, deteriorate.

Spraying is not likely to prove of any practical importance in dealing with this disease.

Conclusion: Finally, it will be seen from what has been said above that, so far as can be judged at present, fungoid diseases are not likely to cause serious damage to cotton cultivation in the West Indies, especially with an improved knowledge of the requirements of the crop. There are, however, diseases present, which are quite capable of causing serious loss should they gain the upper hand. This state of affairs may be brought about by allowing the cultivation to become careless and inefficient, or by slackness in the disposal of dead and diseased plant remains.

SUMMARY.

In the preceding pages a considerable amount of information on a large number of topics is furnished for the guidance of cotton growers in these colonies. An appreciable portion of this information has been obtained at first hand in the Sea Island cotton districts of the United States, and by such means cotton growers in the West Indies are placed in a favourable position for carrying on the industry, while at the same time they are enabled to overcome many, if not most, of the difficulties inseparably associated with starting a new industry.

Great interest is being taken in cotton growing in many parts of the world. The high prices now ruling for all kinds of cotton should stimulate production, and eventually large supplies of cotton will be placed on the British and Continental markets. A fall in prices will naturally follow, and in the long run only the countries, where the conditions of soil, climate and labour are most favourable, will reap the best results.

In the case of Sea Island cotton (the kind recommended for cultivation in the West Indies) the competition of other countries will, probably, be not severely felt. This cotton, recognized as the finest in the world, is a native of these islands. It cannot be grown beyond the influence of sea-air, as it has been shown in Georgia and elsewhere that the quality greatly deteriorates. It will therefore be difficult, if not impossible, to increase the production of this cotton to such an extent as greatly to depreciate its value at any time. In addition to this the tendency everywhere is to use the better sorts of cotton in order to produce finer fabrics, as also articles where a strong fabric is required for goods combining lightness and strength, such as sails for yachts, mail bags, linings for bicycle tyres, etc.

Sea Island (that is long-staple) cotton is now selling at 12*d.* to 15*d.* per ℔., while Upland (short-staple) cotton is selling at 6*d.* to 8*d.* per ℔. It is generally acknowledged that where good Sea Island cotton can be grown, it is useless to devote attention to Upland cotton. This specially applies in the case of the British West Indies, as the areas available here for cotton growing are relatively small as compared with other countries, and it would be futile to attempt to compete in the class of cotton that could be grown over extensive areas, aggregating millions of acres, in Brazil, Peru, the Argentine, West Africa, Egypt and India.

With the view of meeting, as far as possible, the requirements of these colonies, the writers of this report have purposely confined the information contained in it to the treatment of Sea Island cotton. This cotton, it is true, requires more careful cultivation than ordinary cotton; the cotton worm has specially to be guarded against; the picking requires to be performed under close supervision; the seed is to be separated from the lint by means of *roller* gins, and not what are known as *saw* gins. Further, in the baling, Sea Island cotton requires less pressure than is the case with Upland cotton, and the packages are of a different shape. They are usually sent to market in long cylindrical bales resembling 'pockets' of hops.

SELECTION OF SOIL.

The typical cotton soil is described as 'a fine sandy loam' or 'a medium light soil of good average fertility.' It is undesirable to attempt to grow good Sea Island cotton on very poor lands, or those exposed to strong winds. 'Dry shallow soils' are to be guarded against, as also 'wet bottom lands.' Good drainage is essential. In light sandy soils the plants are usually small and the yield inferior; on slightly heavier and richer soils the yield is greater and the fibre stronger; while on heavy clay soils the plants become coarse and leafy, and the return in fibre is small in proportion to the size of the plants. Light and fairly deep soils may be rendered productive by the use of pen and other manures, and irrigation in localities where the rainfall is scanty would be of great advantage. Districts with an annual rainfall of more than 80 inches will probably be found unsuitable for cotton growing. Provided sufficient rain falls during the season of growth, so that the plants attain a fair size, they can afterwards bear comparatively dry and hot conditions.

ROTATION.

It is undesirable that the same land should be replanted two years in succession in cotton. Such a course will probably lead to the exhaustion of the soil and to an increase in insect and other pests. The rotation adopted in the Sea Islands is as follows:--1st. year, cotton; 2nd. year, fallow; 3rd. year, cotton; 4th. year, leguminous crop. Something of the same kind might be followed in the West Indies. In any case, the continual cropping of land in cotton, without high cultivation and manuring, must result in crops inferior both in quantity and quality.

PREPARATION OF LAND.

Hints as to the preparation of land in bush, or lands formerly in canes, together with the probable cost in the different islands have already been published (pp. 225-41). Before the seed is planted the land should be thoroughly forked or ploughed and the heavy clods broken so as to form a fine mould. In well-drained and dry situations the land may remain flat, in others it may be arranged in ridges, 4 feet or 5 feet apart, and the seed planted on the top or side of the ridge, depending on the exposure. In cane lands already holed the seed may be planted on the banks around the holes. It would be of great advantage, in fields where the cotton plants are liable to be exposed to strong winds, to plant beforehand head-rows of pigeon peas and guinea corn in order to afford protection during the early stages of growth. On sugar estates cotton might be planted to leeward of canes to be reaped after the cotton crop is gathered.

SELECTION OF SEED.

The use of good seed and its production by a regular system of selection are just as important factors in the production of good cotton as that of cultivation. It is recommended

that only the best selected seed, obtained direct from the Sea Island cotton districts of South Carolina, be planted in the West Indies during 1904. Such seed may be obtained at cost price through the Imperial Department of Agriculture on application to the local officers in each island. The subject is more fully discussed on pp. 311–13.

DISTANCE APART.

The distance between the plants will depend on the soil and situation. In light soils the plants may be as close as 3 feet by $1\frac{1}{2}$ feet, in slightly heavier and richer soils 5 feet by 20 inches, or 5 feet by $2\frac{1}{2}$ feet. The seeds may be dibbled by hand or by means of a 'planter.' They should be thinned when about 4 inches to 6 inches high, and only *one* plant left in each hole. In light soils the seeds should be planted about 3 inches below the surface; in rather stiff soils 2 inches will be deep enough. The soil should, in every case, be pressed firmly over the seed.

SEASON FOR PLANTING.

The best time for planting will depend on the occurrence of the summer rains. In localities where the rains fall in June, July or August, cotton might be planted in either of these months. In others, the planting may be as late as the beginning of September; but should dry weather set in early in December, cotton planted in September would be liable to suffer. Early planting, when the circumstances admit of it, is regarded with favour as the plants become strong and vigorous before they are attacked by disease. On the other hand, if planted late, they may escape the attacks of the cotton worm, and the expense of treating them with Paris green and lime would be saved.

The season of 1903-4 was so exceptional everywhere on account of heavy rains and high winds, that it is impossible as yet to advise, with any degree of confidence, the exact period when Sea Island cotton should be planted in the West Indies. There is little doubt, however, that advantage should be taken of the early summer rains, whenever they fall, to start the cultivation, and probably it will be found that the planting season will extend in the different islands from the middle or end of June to the beginning of September of each year. It is very undesirable to plant cotton at any time outside these months; and during the present season, at all events, on account of the liability to disease, it would be advantageous not to carry over the cultivation by ratoons into the next season.

CULTIVATION.

During the season of growth the cotton plants require constant attention. The land should be kept free from weeds, the plants moulded up and close watch kept for the cotton worm and other enemies. During the months of September, October and November, or during any period when the cotton worm is expected, the fields should be inspected daily. On the first appearance of the worm Paris green and slacked lime, in

the proportion of 1 to 6, should be immediately applied as directed on pp. 309-10. A single day's delay in the treatment of the worm may entail considerable loss in crop. It is advised that about 3 ℔. of Paris green and 18 ℔. of powdered lime should be kept ready at hand for every acre planted in cotton. The other enemies of cotton are discussed in the preceding pages (pp. 326 et seq.). Paris green may be obtained in large quantity direct from the manufacturers at about 12 to 15c. per ℔. In small quantity it may cost, locally, from 20 to 30c. per ℔. In applying Paris green and slacked lime one or more bags may be attached to a bar as shown on p. 310. When the plants are easily within reach, the bags need not be attached to a bar at all, but held in the hand and shaken above and to windward of the plants.

PICKING COTTON.

A few essential points under this head may be mentioned :—(1) bags to hang from the shoulders should be provided to enable the pickers to have the free use of both hands; (2) at starting the pickers should be carefully shown how to pick cotton quickly without injury to the plants and free from the admixture of bits of leaves, trash, etc.; (3) each morning before they begin work, or after their return in the afternoon, the pickers (without further pay) should go over the seed-cotton gathered by them, before it is mixed in bulk, and clear it of all extraneous matter. By this means they will learn to be more careful in picking the cotton in the field, and so lessen expense to the planter in 'assorting' it before it is sent to the factory. The cost of picking Sea Island cotton should not exceed 1c ($\frac{1}{2}d.$) per ℔. of seed-cotton as brought in from the field. In some parts of the West Indies seed-cotton is picked at the rate of 30 to 40c. per 100 ℔.

DRYING AND ASSORTING COTTON.

Directions under this head are given on pp. 304-5. When seed-cotton has been affected by rain or disease, it should be 'whipped' before it is assorted and dried, otherwise it will be difficult to pass it successfully through the gins. (See pp. 304-5.)

GINNING AND BALING COTTON.

As there are now more than a dozen ginneries in working order in the West Indies, no information is necessary under this head beyond that already given in pp. 305-9. The freight proposed to be charged on cotton shipped from all parts of the West Indies to the United Kingdom by the Royal Mail and other companies is at the rate of 65*s.* per ton weight.

DISPOSAL OF COTTON SEED.

It is urged that no cotton seed be exported from these islands. It should be retained for feeding stock to yield manure in order that its fertilizing properties may be taken back to the land. Hints under this head are given on pp. 323-5. Where convenient the seed may be crushed in a mill or reduced to a fine meal. The cost of grinding cotton seed into a meal

should not exceed 8c. (4*d.*) per 100 lb. Some planters are crushing cotton seed in an ordinary corn and cob crusher. By this means it is possible to crush the seed as required and so prevent its becoming mouldy. Mouldy cotton seed is regarded as likely to be injurious to all kinds of animals. It should be remembered that cotton seed, either whole or ground into meal, is a highly concentrated food, and it should be sparingly given to animals. It would be desirable to mix it largely with other food.

YIELD AND COST OF PRODUCTION.

These, in the case of the Sea Island districts, are discussed on pp. 313-4. It would appear that, in South Carolina, from actual returns of fourteen typical estates, the average yield was at the rate of 204 lb. of lint per acre, that the cost of cultivation and all expenses was at the rate of $35·40 per acre. The returns for the lint and for seed were $57·87, leaving a net profit of $22·47 per acre.

In the West Indies, if we assume that the return in lint is at the same rate, viz., 204 lb. per acre, and the total cost of placing it in the Liverpool market 7*d.* per lb., for cotton fetching 12*d.* per lb., there would remain a net profit at the rate of £5 2*s.* per acre. This would allow for expenses of cultivation calculated at the rate of £3 per acre, ½*d.* per lb. for picking, 1½*d.* for ginning and baling and the balance for freight (65*s.* per ton weight), manure, commission, brokerage, etc.

In the four appendices that follow this report will be found a considerable amount of valuable and interesting information. As this report deals largely with cotton growing on the Sea Islands of South Carolina, the information relating to the physical features of these islands given in Appendix A is likely to be of particular interest, containing as it does particulars of the climate of this region and the chemical composition of typical cotton-producing soils.

The account in Appendix B of the conditions of the Sea Islands in 1880 is especially interesting as indicating the energy and perseverance with which planters in those islands have carried on their uphill work of establishing a prosperous cotton-growing industry.

Appendix C contains suggestions by Mr. Herbert J. Webber, Physiologist in charge of the Plant-breeding Laboratory of the United States Department of Agriculture, as to the improvement in the yield and quality of cotton. This paper should be of great assistance in indicating to West Indian planters the nature of the efforts that have to be made to produce a cotton plant of increased value as to yield and quality.

The last Appendix is the report of an interview with Mr. W. B. Seabrook, whose services have been retained by the Imperial Department of Agriculture as expert ginner. As Mr. Seabrook has been intimately connected for many years with the cultivation and ginning of cotton, his views are particularly worthy of careful consideration.

After a careful review of all the circumstances as existing in the Sea Island cotton districts of South Carolina and the West Indies, we are of opinion that, taking into consideration the difficulties arising from the unreliable character of the labour and the higher rate of wages paid in the United States as compared with the West Indies, the latter should be in a more favourable position for carrying on a successful cotton industry, provided that a suitable selection is made of the localities for cotton growing, and the planters become fully acquainted with the conditions necessary for success.

It has been shown that the quality of the cotton produced in the West Indies is quite as good as the better sorts grown in South Carolina, and it is believed that it may be possible, by adopting skilful and economical methods of cultivation, and introducing labour-saving appliances in the ginneries, for cotton from the West Indies to be delivered at Liverpool at probably less cost than from any part of the Sea Island districts of South Carolina.

APPENDIX A.

PHYSICAL FEATURES OF THE SEA ISLANDS OF SOUTH CAROLINA.

GEOLOGY.

The coast region corresponds almost exactly with the post-pleiocene formation. Its strata of sand, clay and mud have an estimated thickness of about 60 feet, stretching inland some 10 miles and thinning out at a slight elevation above tide water. They rest in Horry and Georgetown on the pleiocene, and for the remainder of the coast, on the eocene, in which occur the phosphate deposits of the Ashley, the Cooper and the Coosaw rivers.

PHYSICAL FEATURES.

In approaching the coast from the sea about the time the white caps of the first breakers are seen, a long, low line of smooth, hard, sandy beach, for the most part of a snowy whiteness, makes its appearance. Immediately inland from the beach swell the undulating ridges of blowing sand, ripple-marked by the action of the wind, in striking similarity to the wave marks of water.

Here the palmetto meets you, standing often solitary and alone, a conspicuous landmark in the picture. Beyond rise the dark green turrets of the pine, beneath which a tangled growth of myrtles and vines is found. Sometimes more than one ridge of sand hills, with an average elevation of 10 or 15 feet must be traversed before the borders of the salt marsh are reached. The salt marshes, their stiff, green reeds rising out of the black ooze visible at low tide, and at the flow apparently floating on the water, with here and there a stray palmetto or a group of under-sized live oaks, their limbs covered with the long, gray moss, form the scarcely varying framework of all landscapes among the Sea Islands. Everywhere these marshes are penetrated by salt rivers and creeks of greater or less width and depth, and surround islands varying from a few acres to many square miles in area. These islands attain a height of 10 to 15 feet—rarely of 25 or 30—above high tide. The mean rise and fall of the tides is 6·9 feet at the mouth of the Savannah river, 6·7 feet at Port Royal, 5·1 feet at Charleston harbour and 3·5 feet at Georgetown entrance, showing a marked diminution as you advance north-east along the coast. The influeuce of the tide extends to a distance of 30 miles in a direct line from the sea, up to the Savannah river, and about 15 miles up the Santee. Salt water, however, usually ascends the Santee river only about 2 miles, and even when the current of the river is diminished in seasons of great drought, not more than 4 miles. Up Georgetown bay it reaches farther, and is sometimes injurious to the crops at a distance of 14 miles. What has been said of the Santee, in regard to fresh and salt water, is true to nearly the same extent of the Savannah river.

SOIL.

The soil of the Sea Islands consists, for the most part, of a fine, sandy loam. This soil rests on a subsoil of yellow sand or yellow clay, of fine texture and deepening in colour, sometimes to red. These clays give a yellow hue to the otherwise grey surface, which is noticed by Mr. Seabrook as indicating lands peculiarly adapted for the production of the silky fibre of long-staple cotton. Besides these soils there are numerous flats, or fresh water swamps, known as bays; here and there a few of these have been reclaimed by drainage; the soil is a black vegetable mould of great fertility, resting on fine blue clay and marl. To a very limited extent, the salt marsh has also been reclaimed; but as yet agriculture has availed itself so little of the vast possibilities in this line, that the chief value of the salt marsh attaches to its use in furnishing forage and litter for stock and inexhaustible material for the compost heap. Low as these lands lie, they are susceptible of drainage. The following analyses will indicate more in detail the character of the soils:

	(1)	(2)	(3)
Insoluble matter	89·368	92·480	58·110
Soluble silica	2·062	0·425	0·328
Potash	0·131	0·200	0·190
Soda	0·077		1·476
Lime	0·077	0·892	0·420
Magnesia	0·038	trace	0·317
Br. ox. manganese	0·154	...	...
Peroxide of iron	0·598	2·490	1·860
Alumina	3·051		1·131
Phosphoric acid	0·163	0·095	0·062
Sulphuric acid	0·154	0·070	0·422
Water and organic matter ...	4·789	2·928	44·865
Carbonic acid	...	0·420	0·840

(1) Is soil from north-east end of James Island, furnished by Elias Rivers, Esq., for analysis, to Dr. Eugene A. Smith, of Tuscaloosa, Ala., and may be taken as a specimen of the less sandy soils of the Sea Islands. Such land will yield 300 ℔. of long-staple lint one year with another.

(2) Is by Prof. C. I. Shepard, of Charleston, of soil from Mr. J. J. Mikell's place on Edisto Island, famous for having long and profitably produced the finest grade of Sea Island cotton, and may be considered as a representative soil.

(3) Is also by Prof. C. I. Shepard, being an analysis of an air-dry specimen of salt marsh.

These analyses will serve to correct serious errors in statements as to the poverty of the Sea Islands, made by J. B. Lyman and J. R. Sypher, in a work on cotton culture, published by Orange Judd & Co., New York. It is stated there (page 129) that a chemical analysis discloses the fact that the soil on an acre of Sea Island cotton land, taken to the depth of 1 foot, contains only 15 ℔. of phosphoric acid and 20 ℔. potash. By the above analyses, however, we find an average of more than $\frac{1}{10}$ per cent. of phosphoric acid, and $\frac{1}{16}$ per cent. of potash. Allowing a cubic foot of earth to weigh 100 ℔. we should have on an acre, to the depth of 1 foot, 4,356,000 ℔., of which $\frac{1}{10}$ per cent. would be 4,356 ℔., showing nearly 2 long tons of phosphoric acid instead of 15 ℔. to the acre. The potash, by the same calculation, would amount to 5,050 ℔. instead of 20 ℔. to the acre. Thus, in the place of being barren for lack of these ingredients, each acre of the Sea Islands possesses an amount which, if rendered available to plant growth, would suffice for the production of over 8,680,000 ℔. of lint cotton, as they do not, by Jackson's and Shepard's analyses, constitute $\frac{1}{20}$ per cent. of cotton fibre. Besides, the salt marsh materials for maintaining and developing the fertility of the soil abound throughout the coast region. There are numerous deposits of post-pleiocene marl on the islands, as at Daton's Swamp, Johnson's Island, Stono Creek, Edisto Island, James Seabrook's Island, Distant Island, near Beaufort and elsewhere. The banks of 'raccoon oyster' shells, peculiar to this latitude, are found in abundance on this coast and furnish excellent and easily accessible stores of lime. These shells are also used for concrete for walls, known as tabby work; the walls of forts several centuries old attesting its durability. Roads and streets are also made smooth and hard by their use. Here, also, in the Stono, Edisto, Coosaw, Bull, Morgan, Johnson's, Beaufort and Broad rivers, and in other creeks and marshes, is found, and largely exported as a fertilizer to foreign lands, the phosphate rock. Experiments have also demonstrated that the fish, so numerous in these waters, may be caught and used for manures.

CLIMATE.

Notwithstanding their proximity to the mainland, the Sea Islands enjoy in a high degree the equable climate peculiar to islands generally. The extremes of temperatures are, as might be expected, greatest in the direction of low temperature; and the cold, which is sometimes injurious to the orange and olive trees, destroys many insects, such as the cotton caterpillar, inimical to vegetation; and of more importance still, it destroys the germs of disease, as of yellow fever and of numerous skin diseases, that flourish in similar regions elsewhere,

preventing them from becoming indigenous, and keeping them exotics for ever, requiring yearly renewal from without.

Notwithstanding the amount of rainfall and proximity to the sea, the climate is not excessively moist, as might be inferred. This is owing to the large number of clear days, averaging about 235 during the year, against an average of eighty-six days in which rain fell, and forty-four cloudy and rainless days. Fogs are of very infrequent occurrence. Vegetation is usually checked by cold for not more than six weeks in the year, from the middle of December to the beginning of February. Nature, that does not allow the inhabitants of higher latitudes to become purely agricultural in their pursuits, forcing them, during the snows and ice of winter, to seek occupation in other arts and industries, here bares her bosom the year round to furnish food and work for man, and seed time and harvest occur in every month.

TILLAGE AND IMPROVEMENT.

The Sea Islands have, since 1866, enjoyed a law, special to them, requiring the owners of live stock to enclose them. Owing to this and to the numerous creeks and marshes that intersect these islands, and which serve as natural divisions, when required, between the different fields, fences are not a burden on the agriculture of the coast lands, and there is comparatively little fencing.

Drainage, although said by Governor Seabrook to be so little attended to on the Sea Islands as to be scarcely worthy of being considered a regular agricultural operation, has of necessity always been practised to some extent. The remarkably high beds on which cotton is planted here, being from 18 inches to 2 feet high, subserve this purpose. The best planters have long had open drains through their fields. These were generally made by running two furrows with a plough, and afterwards hauling out the loose dirt with a hoe, thus leaving an open ditch, if it may so be termed, a foot or more in depth. In recent years the enterprising farmers on James Island have made deeper ditches and placed plank drains in them. Seeing the great benefit resulting from this, they subsequently replaced the plank with regular drainage tile. In this way they have reclaimed a good deal of land, besides adding largely to the value of that already under cultivation. The outlets open to the sea at low-water mark, and the pressure of the water in the pipes preserves a constant outflow even at high tide. So that land only a foot or 2 feet above high-water mark is susceptible of thorough drainage to the depth of 4 or even 5 feet. The borders of these islands being usually their highest parts, and the interior often quite low, a wide field for improvement is offered in this direction.

In the early part of the century, when agriculture had so far developed the value of these lands as to make $60 an acre for planting land not an unusual price, the use of the plough was entirely unknown here, and all the operations of tillage were performed by hand with the hoe alone. This continued to be the usual practice until the war. Since then ploughs have come

more and more into use, until their employment is now quite general.

Fallowing is practised to the extent that land planted in cotton one year is pastured by cattle and sheep, not hogs. It is claimed that great benefit is derived by having the loose soil of the islands trodden by stock during the year they lie fallow. The rapid growth of bushes, briars and weeds is kept down by the stock, and the dried stems of the cotton stalks of the previous year are broken up and trampled down. If care be taken 'that the grass is not eaten so close as to expose the soil on the tops of the beds to the summer sun,' it is found, when the stock are turned off in November to range through the fields, that the pasture 'is in exactly the right condition for the coming season's cotton fields, with no cotton stalks, or troublesome growth to be got off, or under, the land and make it too husky.'

About one-half of the land formerly cultivated is reported as 'turned out' on John's Island, and the same, or a larger proportion, on Wadmalaw. On the other islands less land has passed out of cultivation, but nowhere has the acreage under cultivation increased.

APPENDIX B.

CONDITION OF THE SEA ISLANDS IN 1880.

An interesting article on the condition and prospects of the Sea Islands appeared in the *News and Courier*, the leading newspaper in Charleston, dated April 22, 1880. For a copy of this we are indebted to the courtesy of the present Editor of that journal.

Although written more than twenty years ago, and in days when the cotton industry was just recovering from the effects of the Civil War, it contains information that cannot fail to be of interest to those who are embarking on the cultivation of Sea Island cotton in the West Indies:—

'The description of the conditions of the Sea Islands of South Carolina, published in the *News and Courier* to-day, may fitly be described as a chapter from the Romance of War. Twenty years ago these islands were the homes of planters who, in their opulence and the mingled elegance and comfort of their surroundings, vied with any class of landowners on this continent. Five years later little remained but the ruins of stately residences, and broad fields growing up in rank grass and brush. The whole agricultural and social system of the Sea Islands was overturned, and the undismayed planters who then began anew the battle of life, surrounded by strange and anomalous conditions, encountered difficulties which would have daunted even them, had they been foreknown. At first many of the planters failed entirely, losing what little means had

remained to them and carrying down with them old established firms in Charleston, which had furnished the capital for experimental planting or attempts to follow out the old system under circumstances wholly dissimilar. Only of late years has there been any confidence in the possibilities of the Sea Islands. It is true that the planters themselves knew that they were steadily improving their position, but even in Charleston, to which the Sea Islands are in every sense so near, very little was known of the obstacles that had been overcome, and little is known to-day of the astonishing results which have been actually accomplished. For the purpose of ascertaining what had been done and what was the outlook for their future, we determined to send to the Sea Islands one of the members of the *News and Courier* staff with instructions to see and learn everything necessary to give the general public a complete understanding of the agricultural and social condition and prospects of the Islands on our coast, together with such information as would exhibit in their true light the experiences of the white planters in reconciling and adjusting themselves, as an insignificant minority in point of numbers, to the legions of freedmen by whom they are surrounded. This important work was entrusted to Mr. J. K. Blackman, who visited in succession Edisto Island, Wadmalaw Island, John's Island and James Island, going over the principal plantations and talking as well with the coloured people as with the whites. The results of his tour are published elsewhere, and we shall not do more in this place than give some general idea of his deductions and conclusions.

'There has been, in the first place, an entire change in the system of planting on the Sea Islands. The object now is to increase the yield of cotton to the acre, and this is accomplished by subsoil drainage and heavy manuring. The extent of this drainage can be estimated from the fact that on James Island alone there are 50 miles of subsoil drains, and on one plantation of 65 acres there are 5 miles of these drains. The average cost of such drainage is from \$40 to \$50 an acre. Commercial fertilizers and other manures are applied with a lavishness which, a few years ago, would have been unintelligible. The cost of the fertilizers and manures, alone, ranges from \$20 to \$40 an acre. On James Island, as much as 2,800 ℔. of fertilizer to the acre, exclusive of compost, are now used.

'The increase in the yield of cotton is in proportion to the perfection of the drainage and the judgement and freedom with which the fertilizers are applied. On James Island, where the planting of Sea Island cotton approaches to perfection, the maximum production of lint-cotton (i.e., of ginned cotton) to the acre has risen from 103 ℔. in 1872 to 400 ℔. in 1879. On Edisto Island the production has risen from 80 and 100 ℔. to the acre to 300 ℔. Upon a prize acre on Wadmalaw Island last year, the yield reached the enormous amount of 566 ℔. It can fairly be said, we presume, that the average yield on plantations cultivated by the whites is from 200 to 250 ℔. to the acre. Under the slave system, with large plantations and comparatively little manuring, the average yield was not more than from 80 to 100 ℔. to the acre. This fact demonstrates the

astonishing advance which has been made in the cultivation of long cotton.

'As the yield to the acre increases, the area of the several plantations appears to decrease. The usual size of plantations, for example, on Edisto, Wadmalaw and John's Islands, has been reduced since 1865 from 400 and 500 acres to 50 and 60 acres.

'The profit in the cultivation of long cotton largely depends, of course, upon the price obtained for the staple, and the better price obtained during the past year has had no inconsiderable effect upon the fortunes of the Sea Island planters. A planter on James Island last year, having 65 acres in cultivation, expended *$80* an acre for fertilizers, labour and ginning, and realized a net profit of *$100* an acre. On James Island the average cost of cultivation is $66 an acre with an average yield of 280 ℔. On Edisto Island the cost rises as high as $70 an acre, the average being from $40 to $50 an acre. It is difficult of course, to make any general average, but it is within bounds to say that an average expenditure of $40 an acre with skilful management will produce, under favourable conditions, 220 ℔. of cotton to the acre, which at 40 c. per ℔. will bring $88, leaving a net profit of *$48* for each acre under cultivation. The 566 ℔. of cotton made on the prize acre of Wadmalaw cost the planter $80 when delivered in Charleston, and at 40c. per ℔. produced $226, leaving a net profit of $146. There is no need to hunt for gold mines when such profit as this can be pleasantly and safely made on the coast of South Carolina.

'It will be said, no doubt, that there is almost as much uncertainty in cotton planting as in gold mining, by reason of the occasional visits of the planter's old plague, the caterpillar or cotton worm. As a matter of fact, however, the Sea Island planters no longer take the caterpillar into serious account, and do not dread its coming. Thorough drainage and the application of various mineral compounds to the growing plant have so reduced the injury done by the caterpillar that the white planters are not affected by it. With the coloured planters it is different. For reasons which Mr. Blackman gives, they are unwilling to apply adequate preventives, and suffer in proportion. The caterpillar, on the whole, need no longer be considered an element of risk in Sea Island planting.

'The profitable character of Sea Island planting under the new system has largely enhanced the value of suitable land. It is difficult to ascertain what the best plantations would bring in the market, as few of them are now offered for sale. Twelve or fifteen years ago they brought a nominal price, and now they are probably worth as much as in 1860, when the increment of negroes was an important element of value. On Wadmalaw Island, good cotton land was estimated to be worth from $40 to $50 an acre, and on Edisto from $50 to $75 an acre. A planter on James Island informed Mr. Blackman that he would not accept $60,000 for 600 acres, and another planter on the same island values his land at $200 an acre.

'For some time after the first revival of Sea Island planting, there was difficulty in obtaining the labour required, inasmuch

as the freedmen desired to have an opportunity of making fortunes themselves. The plans now in vogue give the planter a fixed amount of work in exchange for the use of a specified amount of land. Under what is known as the "two-day" system, each labourer works for the planter two days in the week, receiving in return the use of from 5 to 7 acres of land for his own purposes, and receives generally in addition a residence, free of rent, and as much wood as he requires. Another plan is for the labourer to enjoy the use of 5 acres of land and cultivate in return 2 acres for the planter to whom the land belongs. These methods are found to work well, but the planters are somewhat apprehensive that there will ultimately be a serious deficiency in available labour, in consequence of the steady acquisition of land by the coloured people, which they cultivate for themselves in preference to working on any terms for other planters. As the coloured people improve their condition, their desire to labour exclusively for themselves very naturally grows stronger. We do not doubt that planters who have solved so many perplexing problems will find ways to obtain what labour is necessary, without retarding the desirable progress of the freedmen and their families.

'There are now no Northerners among the white planters on the Sea Islands. At different times northern men with abundant capital have undertaken to plant long cotton on the islands, but their unfamiliarity with the peculiar culture of cotton, coupled with their extreme confidence in their own theoretical knowledge, caused them sooner or later to fail entirely. The planters on the islands at this time are exclusively those who have had experience in cotton growing, and those most successful are the planters, who unhesitatingly discard whatever in the old system is found to be incompatible with the requirements of the prevailing low prices and of free labour.

'Little else than long cotton is grown on the Sea Islands. Some corn is made and an inconsiderable quantity of small grain. Tobacco, however, has been successfully grown on John's Island, the cigars manufactured from it selling as high as those imported from Havana.

'A most gratifying circumstance is the excellent and friendly understanding, which exists between the coloured people and the white planters. This has conspicuously strengthened since the election of Governor Hampton in 1876. The coloured people take no interest in politics, except when they are excited in election times by the periodical visits of the professional politicians. This is the only drawback of the coloured people, and the only element of irritation between them and the whites. The reason is that the coloured people are always treated by the republican leaders to exhortations and menaces which are intended to convince them that the white people, amongst whom they live in peace the whole year round, are their worst and deadly enemies. The effect of this is temporarily as disturbing as though the coloured people, now so prosperous, were, as their stump-speakers declare, in danger of being returned, in some way, into slavery. . . . .

'The improvement in the condition of the coloured people is equally amazing and gratifying. At the public schools the attendance is large, and there is a decided improvement in the sense of moral responsibility. Petty thefts are now comparatively rare, and the planters on Wadmalaw and Edisto Islands say that they do not even find it necessary to lock their doors at night. The coloured people have good houses, and their food is better than formerly. They are well supplied with horses, and own a considerable number of pleasure vehicles. On Edisto Island alone the coloured people bought 500 horses and mules, 300 carts and 100 buggies in the course of a year. There are few coloured men who do not own either a horse or a mule. They now own a considerable quantity of arable land. On John's Island they have 4,300 acres, on James Island 1,600 acres, on Wadmalaw 500 acres, and on Edisto they have 4,000 acres, and make two-thirds of the entire cotton crop of the island. The aggregate is over 10,000 acres, which must be worth at least $300,000.

'The coloured people make cotton more cheaply than the whites can do, but their plantations are not properly drained, and they do not use fertilizers as liberally as is done by the whites. The yield of cotton on the plantations of the coloured people is from one-third to one-half less than the crop made on corresponding lands by the whites. Generally, the coloured people do not accumulate much money. They pay their debts promptly enough, but live fully up to their incomes. They want to be comfortable and are willing to pay for it.

'The description given by Mr. Blackman of the Coloured Co-operated Plantations on Edisto Island is particularly instructive and interesting, as is the account given of a coloured man named John Thorne, who owns several hundred acres of land, a store-room and six cotton gins, and it is reputed to be worth $20,000. Thorne is a capitalist in his way, and furnishes supplies to impecunious white and coloured planters in his neighbourhood. The rate of interest on these advances ranges from 15 to 20 per cent. a year, which is not more, it must be conceded, than white lenders charge under similar circumstances. The legal rate of interest in South Carolina is 7 per cent. On advances for agricultural purposes, the average rate of interest on the Sea Islands has decreased in twelve or fifteen years from as high as 75 per cent. a year to about 15 per cent.

'The facts we have given show the astonishing adaptability of the southern character, the power of the southern planters to conform themselves to novel and confusing conditions, their ability to live in peace and comfort in the midst of bodies of coloured people outnumbering them a hundred to one, and the fundamental truth that, where the whites succeed and prosper, the freedmen, under the influence of their example, succeed and prosper likewise. As far as the Sea Islands of South Carolina are concerned, the southern problem is solved, and there is no room to doubt that the fortunes of these Islands, in the absence of political agitation, will continue to improve. Their happy position to-day is a living witness to the courage,

the perseverance, the intelligence and the industry of the Sea Island planter, and is a promise, also, of additional business for Charleston which lost, in trade and otherwise, by the early failures of the planters, many million dollars which will be restored, in course of time, as the Sea Islands become once more our best and safest customers.'

APPENDIX C.

IMPROVEMENTS DESIRABLE TO BE SOUGHT IN INCREASING THE YIELD AND QUALITY OF COTTON.

The following valuable suggestions in reference to the improvements desirable to be sought in cotton are reproduced from a reprint from the *Yearbook of the United States Department of Agriculture* for 1902 (pp. 379-86), by Mr. Herbert J. Webber, Physiologist in charge of the Plant-breeding Laboratory :—

INCREASED YIELD OF FIBRE AND SEED.

'The possibility of increasing the yield of fibre and seed has been the main feature discussed heretofore in this paper, and need not be referred to here further than to state that numerous instances and experiments show that very marked improvement can be obtained by a few years of selection from the best yielding plants. The result obtained by the writer in the selection of Egyptian cotton, to be described below, forms a good illustration of increase in yield produced by only three generations of selection. The gradual increase in the yield of Sea Island cotton since its introduction is also in part to be attributed to the careful selection to which it has been subjected, although improved methods of culture have contributed to the same result. In wheat, corn, and many other agricultural crops remarkably increased yields have frequently been secured by careful selection experiments, the exact results of which are in many places on record and can be examined by the student.

INCREASED LENGTH OF STAPLE.

'In all varieties of cotton there is considerable variation in the length of the staple produced by different plants, and by the selection of seed from those plants having the longest staple : following the methods described above, the average length can be greatly increased. Very remarkable results in increased length of staple of Sea Island cotton have been produced by the careful selection to which it has been subjected, as described by the writer in the *Yearbook of the Department of Agriculture* for 1898.

'One of the most striking instances of improvement in both length and abundance of fibre, that has come under the writer's observation, is a selection of Stamm Egyptian cotton at Columbia, S.C. The few seeds of this variety imported had the lint attached, as when taken from the boll, and the average length was only about $1\frac{1}{4}$ inches. The plants of the first generation in this country were very tall, some of them reaching a height of 8 feet, and very unproductive. Seed from several of the best plants, which were nevertheless inferior, was selected and preserved for planting the second season. The second season the lint from some of the plants was much longer, more abundant, and of better quality than that from plants grown from imported seed. The progeny in the second year, grown from the first-year selection, were uniformly earlier, much more productive and had longer and better lint. The lint on some plants was remarkably abundant and uniform, and in a number of instances reached the length of $1\frac{3}{4}$ inches. As a result of two years of careful selection in this country the character of the staple had thus been entirely changed and improved.

UNIFORMITY IN LENGTH OF FIBRE.

'Uniformity in length of fibre is a feature of primary importance and long-staple cottons especially are capable of much improvement in this regard. This is one of the qualities regularly considered by the Sea Island planters in making their selections. Griffin, one of the best long-staple Upland cottons now grown, is lacking in uniformity, and should be carefully selected to improve this character. While the majority of the fibres range in length between $1\frac{1}{2}$ and $1\frac{3}{4}$ inches, the fibres near the point of the seed are frequently much shorter than those on the base and middle: and, again, some of the middle fibres are usually very long, frequently reaching a length of from 3 to $3\frac{1}{2}$ inches. This lack of uniformity in length could probably be corrected by a few years of careful selection. In selecting to secure uniformity it is not enough to judge simply by the regularity of all the fibres on the same seed. Seed from different bolls on different parts of the plant must be examined to see that the fibre on the different seeds is of the same length or nearly so. A general tendency to produce fibre of the same length throughout should be bred in the plant. If long-staple cotton is variable in length of fibre, there is considerable waste in the process of manufacture, and the value of the staple is impaired. Careful attention must therefore be given to this point in the selection and improvement of all long-staple varieties.

STRENGTH OF FIBRE.

'Another essential consideration, which has great weight in determining the value of cotton, is the strength of the fibre, in which many varieties are lacking and to which careful attention should be given. The long-staple Upland cottons, especially those which have thus far been introduced, are very inferior in this quality. The majority, if not all, of these varieties were originated by crossing ordinary Upland cotton with Sea Island, and the almost universal tendency of such hybrids is to pro-

duce fibre deficient in strength, although it may be long and silky and approach Sea Island in these respects. Housewives in recent years complain of the weakness of thread, and this may be due in part to the lack of strength of long-staple Upland cotton, which is largely used in the manufacture of thread. In the selection of Sea Island cotton great care is given to the character of strength, and the fibre of this cotton when properly grown is probably as strong as that of any other cotton, unless it be properly grown Egyptian cotton, which is also exceedingly strong. Sea Island cotton, because of its strength, has been selected after careful tests as producing the strongest and most durable duck cloth for United States mail sacks.

SEASON OF MATURING.

'In all varieties there is considerable variability in the season of maturing, and this furnishes the means of securing modifications in this respect. If an early strain is desired, much can be accomplished by selecting seed always from the earliest plants, most of our early varieties having been produced in this way. In the case of the big-boll varieties, such as Truitt, Christopher, Russell, Texas Storm Proof, etc., the season of maturity is so late that they are not profitable to grow in northern cotton sections. It is desirable that early strains of big-boll sorts be produced.

ADAPTATION TO SOIL AND CLIMATIC CONDITIONS.

'Varieties which have been highly selected have by this selection been adapted to the soil and climatic conditions existing where the selection was carried out. If such plants are grown under different conditions they may fail to give equally good results and may require to be bred and reselected in order to adapt them to the new conditions. A pertinent illustration of this principle is furnished by the results that have been obtained in the introduction and breeding of Egyptian cottons in this country. Egyptian cotton is similar in most respects to Sea Island, being distinguished mainly by the character of the fibre, which is much coarser than Sea Island, very crinkly and woolly, and ordinarily of a light-brownish colour. The yield in Egypt, as reported by Messrs. Kearney and Means, who have recently visited that country in connexion with these experiments, is frequently from 600 to 800 ℔. of lint per acre, being much more than is ordinarily secured from our best Upland cottons. When the best imported seeds of Egyptian varieties are planted in this country they almost invariably produce the first year very tall spindling plants, which set very few bolls. The writer has had this experience with seed of Ashmouni, Abbasi, Mit Afifi, Gordon Pasha, Jannovitch and Stamm grown in South Carolina, Georgia and Florida. The many attempts at growing Egyptian cotton in various parts of the cotton region of the United States have met with such poor success that planters have given it up as impracticable, and the impression prevails generally that the cultivation of Egyptian cotton in this country is a failure.

'In 1899, the writer grew a few plants of Ashmouni Egyptian cotton at Columbia, S.C. They were, as above stated, very spreading and open, and set but few bolls the first year. The fibre also showed a tendency to lose its curliness and become whiter than the imported article. The most prolific and earliest plants showing the characteristic Ashmouni lint were selected. Seed of these was planted again in 1900, and selections of the best again made as in 1899. The same process of selection was repeated a third time in 1901. In 1902, the selections were transferred to Hartsville, S.C., where they were planted on similar soil. This season, the fourth in the United States and the third generation of the selection, they gave very promising results. A number of plants not true to type were pulled up, and the total production was thereby reduced, yet a yield of 1,303 ℔. of seed-cotton per acre was obtained which gave 479 ℔. of lint per acre. The fibre produced was typical Ashmouni in every respect observable, and proved on comparison to be slightly longer than the best samples of this variety obtained by Mr. T. H. Kearney in Egypt. It is markedly superior to the strain of Ashmouni used in starting the selection both in quantity of lint on a seed and its length and uniformity. A field of Mit Afifi Egyptian cotton was grown on the same soil about ¼ mile distant, planted with seed directly imported. In Egypt this variety ordinarily gives a larger yield than Ashmouni, but at Hartsville, under the same conditions of soil and fertilization, it gave a yield of only 960 ℔. of seed-cotton and 346 ℔. of lint per acre.

'By selection in the same way Stamm Egyptian cotton has been very markedly improved in length and quantity of fibre.

RESISTANCE TO DISEASE.

'The apparent possibilities in the development of disease-resistant strains offer a promising field for systematic breeding and selection. It has long been known that in various plants some varieties will resist certain diseases to which other varieties are susceptible. As an illustration, the sour orange is resistant to foot-rot, or *mal di gomma*, which is caused by a parasitic fungus, and the disease is universally controlled by budding or grafting the susceptible sweet orange on the resistant sour orange stock. A similar case of resistance among oranges to a disease caused by a surface-feeding mite has also been discovered by the writer. The Drake Star orange, a late variety of good quality but a light bearer, was found to be almost wholly resistant to attacks of the orange rust-mite, trees of this variety in the centre of badly diseased, sweet seedling groves producing fancy bright oranges, showing almost no effect of injury.

'Experiments recently made by Mr. E. L. Rivers, of James Island, S. C., and Mr. W. A. Orton, of this Department, have shown conclusively that strains of both Sea Island and Upland cottons can be produced by selection which are resistant to the attacks of "wilt" or "black root," a serious disease of cotton which is causing great damage to the industry in South Carolina, Georgia and Alabama. The method of breeding such

immune strains is very simple, and it is easily possible for every planter having the disease on his plantation to breed a resistant strain. In fields of Sea Island or Upland cotton planted on soils badly infected with the wilt fungus, almost every plant is killed by the disease before producing any cotton. Usually, however, a plant here and there will be observed which remains unaffected and produces a fair crop. By selecting seed from such immune plants and planting it again on badly infected soil, it has been found that the quality of immunity is usually transmitted to the progeny in a wonderful degree, and by carrying out such selections and planting each year on badly infected fields, Mr. Orton has been able to produce strains of both Upland and Sea Island cotton which are immune to the disease. Several varieties of Egyptian cotton tested in fields infected with the wilt fungus were found by Mr. Orton to possess a high degree of resistance. Jackson Limbless, one of the standard Upland varieties, was also found to be much more resistant to the disease naturally than any other of the ordinary Uplands, but was not so resistant as the Egyptian sorts.[a]

'The Iron cow pea was found by Mr. Orton to be resistant to the cow pea wilt, a parasitic fungous disease, and by the writer, in conjunction with Mr. Orton, it was found also to be almost absolutely immune to attacks of the root-knot nematode (*Heterodera radicicola*).[b] Sugar beets resistant to the sugar beet nematode are also being bred by Wilforth, who has met with considerable success.

'In the control of cotton diseases the breeding of immune strains bids fair to be of the greatest importance, as the evidence at hand indicates a considerable difference in the resistance of various individual plants in the case of several maladies, though in no case with cotton, other than in the cotton wilt, has it been shown that this apparent immunity will be transmitted. In the case of the Mexican boll-weevil, which has overrun Texas and threatens to destroy the whole cotton industry, if no check to its spread is found, there is some evidence to indicate that strains of cotton resistant to this insect may ultimately be bred. In examining fields of Upland cotton in different parts of Texas, occasional individual plants were observed by the writer in badly infected fields which had set and matured almost all of their bolls, while adjoining plants were almost denuded of their bolls, except a few of the earlier maturing ones, which had developed before the weevils had become abundant. Whether such plants possess a degree of resistance or not, and whether this possible resistance will be transmitted to the progeny, remain to be determined. It seems probable that some plants may be discovered and propagated which will be distasteful to the weevils.

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a. Bulletin No. 27, Division of Pathology and Physiology, United States Department of Agriculture. 'The wilt disease of cotton,' by W. A. Orton.

b. Bulletin No. 17, Bureau of Plant Industry, United States Department of Agriculture. 'Some diseases of the cow pea,' by H. J. Webber and W. A. Orton.

'In the seasons of 1901 and 1902 the writer, in conjunction with Mr. A. W. Edson, of this Department, grew patches of certain varieties of Egyptian cotton in several parts of Texas. As Egyptian cotton is noted for its freedom from diseases, the effect of the boll-weevil on the several varieties was watched with considerable care. A patch of 2 acres of Jannovitch Egyptian, grown at Pierce, Tex., in the season of 1901, was very badly injured by the weevil, giving a yield of only 15 ℔. of seed-cotton on 2 acres. A small field of Ashmouni cotton at one place in 1902 was also badly injured, showing that this variety was probably as susceptible to attack as any other sort. A field of Mit Afifi cotton, of 3 acres, grown at San Antonio, Tex., on the irrigated plantation of Mr. F. F. Collins, gave results which may indicate a degree of immunity, though further trials are necessary before the matter can be satisfactorily settled. The 3 acres of Mit Afifi were grown on land where the cotton crop had been destroyed by weeviis the previous year. Near the Mit Afifi, about 200 feet distant, was a small patch of Upland cotton of a little over $\frac{1}{4}$ of an acre in extent, a small patch of sugar-cane intervening. The weevil did not appear on the patch of Mit Afifi until the middle of October and when the patch was last examined by the writer in the latter part of October, the weevils had not yet become abundant. The weevil appeared on the patch of Upland cotton early in the season, and the crop was entirely destroyed, only a comparatively few of the early bolls maturing. Throughout the season the weevils were abundant on the Upland patch, while at no time did they become so abundant on the Egyptian cotton. The Egyptian variety gave a yield of 3,200 ℔. of seed-cotton, or about 1,066 ℔. per acre; while the Upland variety gave a yield of 58 ℔. of seed-cotton, or about 200 ℔. per acre. It has been found by investigators and planters that, in general, early varieties are less affected by the boll weevils than late varieties. When the weevils first appear they are few in number, but gradually increase as the season advances. Very early varieties may set a large share of their bolls before the weevils become so abundant as to destroy all of the forms and young developing bolls. The Upland cotton was much earlier than the Egyptian and would normally be expected to produce a much larger crop in boll-weevil districts owing to this fact. The striking freedom of the Mit Afifi field from injury by the weevil would indicate that the plants may be in some degree distasteful or resistant to weevil attacks, although this cannot be definitely determined without further experiments. Among the Egyptian plants a very few volunteer Upland cotton plants developed, and these, as a whole, remained fairly free from injury by the weevil until late in the season and gave a nearly normal yield. The Egyptian plants were about 2 feet taller than the Upland plants and entirely surrounded them. The fact that these few Upland plants in the field of Egyptian cotton produced fairly well led several persons examining the field to conclude that the absence of weevils in the Egyptian field was entirely accidental. While this may be the case, we are equally justified in assuming that the Egyptian variety, if distasteful and resistant, would in some measure protect from attack the few Upland plants which they surrounded and overshadowed.

'If the Mit Afifi Egyptian cotton is in any degree resistant to attacks of the boll-weevil, as is suggested by the above experiment, it would be of great importance in the investigation of the boll-weevil problem, for if it possesses any degree of immunity, this could probably be greatly increased by a few years of careful selection. In view of the knowledge of the resistance of varieties of other plants to various insect and fungous diseases it would not seem at all impossible or improbable that a variety of cotton might be found, that would be resistant to the boll-weevil. In experiments of this kind, however, it must be rembered that a variety resistant to a disease under certain conditions, if these conditions are changed, may become subject to attack.

'Anthracnose, or boll rot, another serious disease produced by a parasite fungus, is much worse on certain varieties than on others, and individual plants have been observed to vary considerably in degree of susceptibility. Here again there is evidence of an opportunity for the plant breeder to secure material for experiments in the breeding of immune varieties.

STORM RESISTANCE.

'In many parts of the country where severe wind or rain storms are common, the cotton is torn and beaten out of the bolls, causing considerable damage. The form of the open bolls in certain varieties prevents the cotton from being blown or beaten out so easily, so that there are some so-called storm proof varieties. There is opportunity for considerable improvement in this direction by systematically selecting seed from the plants suffering the least damage from this source.

CONCLUSION.

'In this paper the writer has attempted to describe both simple and complex methods of selection, which may be used by cotton planters and breeders, and to point out some of the important improvements, and results that can be produced by such means. It is impossible to overestimate the importance of seed selection to the planter. It is one of the fundamental principles of successful cotton growing, and planters are earnestly urged to give the matter careful consideration and adopt a systematic method of seed selection.

'The writer has also pointed out a few of the many important improvements which could possibly be obtained by careful breeding, in the hope that some planters may be induced to carry out experiments looking to their accomplishment.'

APPENDIX D.

REPORT OF A VISIT TO THE BARBADOS COTTON FACTORY.

INTERVIEW WITH MR. SEABROOK.

Yesterday morning, January 29, 1904, an *Advocate* representative paid a short visit to the Government Cotton Factory on the Pierhead for the purpose of viewing the gins in motion, and found every one on the premises busy at work in attending the gins, crushing the cotton seed into meal, and baling the cotton ready for shipment. The whole process seemed very simple, although it is absolutely indispensable where a large quantity of cotton has to be freed of its seed and made fit for exportation. There seemed to be a fair quantity of cotton in bags on the premises waiting to be 'passed through' the gins and baled, and close by there were many bales ready for shipment. The work is at present carried on under the superintendence of Mr. W. B. Seabrook, who, as is now pretty well known, is the expert ginner whose services have been engaged by the Imperial Department of Agriculture for the West Indies. Although hard at work, Mr. Seabrook courteously placed himself at our representative's disposal. The first thing that attracted our representative was the keen eye kept on everything around him by the expert, and the close attention especially paid to the gins led to the conclusion that much care is necessary in handling them to prevent them from being damaged. Our representative was tempted to ask Mr. Seabrook how long he had been engaged in this line of business, and whether he had any knowledge of the industry outside of the factory. To this question Mr. Seabrook replied: 'I have seen nothing else all my life but cotton growing and ginning. My ancestors were cotton growers, and my brother, Mr. F. P. Seabrook, is one of the principal cotton growers on James Island, South Carolina. I have also a brother-in-law, Mr. E. L. Rivers, of James Island, whom you must have heard of in connexion with what is known as the Rivers cotton—a variety which originated with him in co-operation with the U.S. Department of Agriculture. This variety is the result of the seed of a single plant which had survived the wilt disease, while the surrounding plants had been killed, in Mr. Rivers' experiments to procure a resistant variety. I used to be a cotton grower myself, but thirty years ago I decided to devote my attention to ginning; and I may say, with some degree of modesty, that many of the improvements that have been made in the Macarthy gin have been made through my observation.'

Asked what he thought of the cotton worm, Mr. Seabrook said: 'I have not seen the worm in your cotton, but I know what it is like. It is no doubt like the caterpillar with which I am familiar, and which is easily controlled by the use of Paris green.'

Mr. Seabrook was then asked if there was anything in connexion with the cotton he had been receiving at the factory, which he thought required to be remedied.

'The most serious thing,' he said, 'that I have noticed is that there is a great deal of short staple mixed with the long staple, and this machine cannot gin short-staple cotton.'

'What is the remedy for this?' was the next question put.

'The first thing to be done, I should say, would be to get the best seed that can be obtained, and make experiments with it. These experiments should be thoroughly carried out. They should be given close attention and every possible chance to obtain the best possible results. When a good variety is established, the growers should exercise their intelligence with the view of keeping up, and if possible improving, the quality of the staple, having due regard to local conditions.'

What is your opinion as regards our factory?

'Well,' replied Mr. Seabrook, 'it is as near perfection as I can imagine. It is solid and substantial in all the details of its construction. The boiler and engine are very substantial, and neat in finish, with abundant power to supply all demands with a comparatively low pressure of steam, say, 60 ℔. As you will see, the room in which they are located is a picture of neatness and solidity. The gins are securely anchored to a massive foundation of concrete, which is artistically finished with a beautiful plastering of Portland cement, which not only gives attractiveness to its appearance, but secures to the gins that solidity that effectually gets rid of all vibration while in operation. The gins themselves are of the latest make, and are everywhere conceded to be the most substantial gins used in ginning long-staple or Sea Island cotton; and as soon as the operators get broken in to the work, they are fully capable of giving much more than 300 ℔. of lint cotton per hour to the set of six gins.'

How does it compare with similar factories in the Sea Islands?

'I have no hesitation in saying that I have never seen a more substantial ginning plant in the Sea Islands of South Carolina and very few can enter into comparison with it on those lines. There are differences in details for facilitating operations, economizing time and labour, etc., which vary according to the ideas of different proprietors; but for substantial construction and thorough equipment for work this factory will bear comparison with the best. But for getting the largest results from the gins it is necessary to have a uniformity in the staple of the cotton. A Macarthy gin cannot gin short-staple cotton; and when this is mixed up with that of a long staple the result is very small indeed. In fact, the first important step in planting cotton, with any hope of achieving success is, as I have already said, to secure *good seed*—seed that can be guaranteed to be uniform in length and fineness of staple or as near so as it is possible to be. It is as reasonable to put a cur in competition with a finely bred setter, and hope to get the prize, as to put cotton of mixed quality and staple in

the market and expect to get the same price as that which has uniformity.'

What are the important conditions in turning out a good class of cotton?

'The second essential point for success is that which constitutes the first, and a most important step in the preparation, viz., clean picking. Trash in cotton is nearly always the result of carelessness and indifference and should not be tolerated. No gin has ever been invented, or ever will be, which can take it out. It is as easy to pick it clean as to pick it otherwise; and if, when a picker takes the lobes of cotton from the boll, he or she would just glance at it and pick off any leaf that may be adhering to it, there would be no trashy cotton.

'There is one exception to this, and that is when cotton that is ready to be picked is caught in a spell of rainy and blowy weather, it then gets trashy unavoidably. When picked, this trashy cotton should not be put with the bulk, but should be put by itself until dried and whipped to get out all the trash possible.

'The second step necessary to a good preparation of cotton is to have it overhauled, or, as it is called, assorted—all the stained and rotten cotton picked out—before it is sent to the gin. It is presumed that every one understands the necessity of sunning and thoroughly drying his cotton as soon after picking it as possible. It should never be closely bulked until thoroughly dried.'

Can you offer any suggestions or advice to the planters as to the manner in which they could assist the factory in providing long-staple cotton of high quality?

'I can only recapitulate the conditions necessary for success, namely,—1st., good seed; 2nd., careful picking and drying; 3rd., assorting it clear of trash If these conditions are observed there is no reason why a perfect sample should not be furnished by the gin, and the best market prices obtained for that quality of cotton.

'Now this *good seed*, of which I speak, and which is so essential to success, would be best obtained where Sea Island cotton is raised in its highest state of perfection—the Sea Islands of South Carolina, and especially those nearest to Charleston. The selection of cotton has long been a study with many planters there, and good uniform seed, as to length and fineness of staple, can be obtained from them to start with. Thousands of bushels of Sea Island cotton are used every year for fertilizing purposes—planters refusing to plant it because of deterioration. This could be had for very little; but if unfit for planting there, it would be unfit here. So it is necessary to get seed from a reliable person, and one who will vouch for its purity. The difference in cost will be a very small item in comparison with the difference in result. Once the strain is established here, enterprising and intelligent planters could commence and perfect selections for themselves, and thus keep up a supply of fine, long-staple cotton for the

gins which are so fully able to put it in the market to the best advantage.

'With regard to the cultivation and improvement of cotton, I notice in the *West Indian Bulletin*, the journal of the Imperial Department of Agriculture (Vol. IV, No. 3) some articles that should meet the needs of local growers; and any thing more that I may say in the direction of cultivation, etc., would practically be a repetition of the views contained therein. I would advise growers to read and re-read that number of the Department's journal carefully, and they will learn much that will prove most useful to them in the production of good long-staple cotton.'

With a cotton grower and ginner such as Mr. Seabrook undoubtedly is, the British West Indies should be able, if sufficient care be exercised on the part of growers, to put a very saleable article in the cotton markets of England, for they can get from him the benefit of his experience in precisely its most valuable form,—namely, the highest expert knowledge.

ERRATA IN THE PRESENT VOLUME.

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Page 189, line 19, *for* Wright *read* Wight.
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Page 195, line 14 from bottom, *for* supports *read* sports.
Page 313, line 8 from bottom, *for* 117 *read* 17.

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Second Assistant	E. J. WORTLEY.
Fermentation Chemist ...	CHARLES ALLEN, B.Sc.

Lecturer in Agricultural Science	T. F. TEVERSHAM.
Travelling Instructors in Agriculture...	WILLIAM CRADWICK. WILLIAM J. THOMPSON.
Agricultural Instructor at Hope Experiment Station	THOMAS J. HARRIS.

BRITISH GUIANA.

Botanic Gardens.

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Superintendent	A. W. BARTLETT, B.A., B. Sc., F.L.S.
Head Gardener	JOHN F. WABY, F.L.S.
Assistant Gardener ...	F. W. B. CARTER.
Clerical Assistant ...	E. S. CHRISTIANI.
Berbice—	
Keeper	J. NARDAMOONIE.

Sugar-cane Experiments, etc.

Chemist-in-charge	Prof. J. B. HARRISON, C.M.G. M.A., F.I.C., F.G.S., F.C.S.
Agricultural Assistant ...	ROBERT WARD.

TRINIDAD.

Royal Botanic Gardens.

Superintendent	JOHN H. HART, F.L.S.
Asst. Superintendent	F. EVANS.
Head Gardener (Govt. House)...	J. BAILEY.
Clerk (St. Clair)...	H. C. MASSY.
Foreman (St. Clair)	J. C. AUGUSTUS.
Herbarium Assistant	PAULINE MCLEAN
Agricultural Instructors ..	WILLIAM LESLIE H. A. NURSE.

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